



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

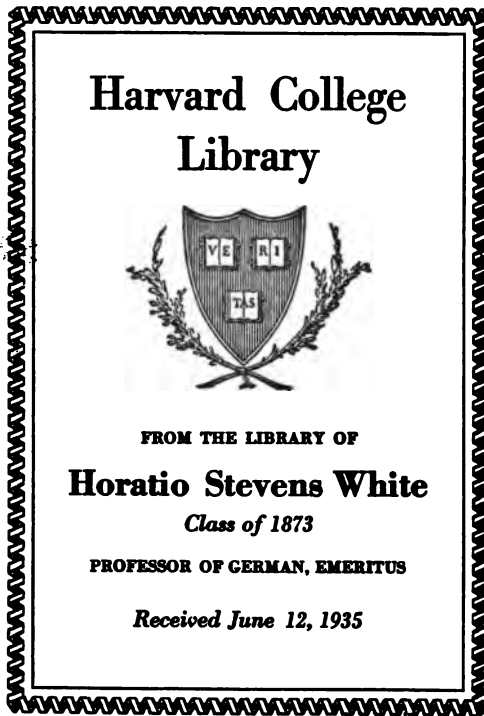
We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>

Sci 1520.432



SCIENCE CENTER LIBRARY

THE COMPASS.

A MONTHLY JOURNAL

FOR ENGINEERS, SURVEYORS, ARCHITECTS, DRAUGHTSMEN,
AND STUDENTS.

Volume 1.--1891-1892.

EDITED BY
WILLIAM COX.

NEW YORK.
KEUFFEL & ESSER CO.,
127 FULTON ST.

Sci 1520.432^Δ
✓

HARVARD COLLEGE LIBRARY
FROM THE LIBRARY OF
PROFESSOR HORATIO STEVENS WHITE
JUNE 12, 1935

COPYRIGHT 1891—1892 BY WILLIAM COX.
NEW YORK.

INDEX.

ACCURACY of Slide Rule Computations.....	124
Adder, Webb's.....	103
Adding Machine, Universal.....	101
Adjustments of Surveying Instruments.....	41
Arithmethical Mean	21, 56
Arithmethical Progression	10, 56
Assortment of Handy Instruments for the Draughting Room.	
	113, 149, 168
Average Steam Pressure.....	17, 44
Average Steam Pressure and H P. Indicator.....	52
BEAM Compasses.....	169
Blue Process Paper.....	60
Books, New.....	7, 48, 119, 167
Both's Section Liner.....	189
Boucher Calculator.....	82
Bubble Measurements.....	104
CAN Aluminum be advantageously employed in the construction of Geodetic Instruments?.....	8
Celluloid.....	67
Centrolinead, The.....	13
Charpentier Calculator.....	81
"Comfort" Drawing Table.....	151
"Columbia" Indelible Liquid Inks.....	24
Compass for a Watch.....	93
Compass Variations.....	2
DECIMAL Divisions of the Circle.....	128
Decimal Point in using the Slide Rule.....	137
Drawing Instruments, The best.....	6
Drawing Pens.....	149
Drawing Table, The "Comfort".....	151
"Duplex" Slide Rule, The.....	63, 80

ENGINEERING and Surveying Instruments.

3, 19, 35, 49, 68, 84, 104, 115, 141, 156, 172, 180	
"Excelsior" Steel Tapes.....	34
Extension Tripod, A New.....	16
FINDING the Decimal Point in using the Slide Rule.....	137
Formula for Delivery of Pumps.....	16
Fuller's Spiral Slide Rule.....	66
GEOMETRICAL Mean.....	21, 57
Geometrical Progression.....	10, 57
Gradienter Attachment, The.....	115, 141, 156
Gradienter Tables.....	156, 172, 180
HELIOGRAPHIC Paper.....	60
How to determine the Position of Vanishing Points in Perspective Drawing.....	98
IMPROVED Leveling Target.....	125
Influence of the Moon on the Barometer.....	183
Instrument Adjustments.....	41
Inverted Scale.....	58
Is the Mariner's Compass a Chinese Invention?.....	76
LATITUDE and Departure with the Slide Rule.....	75
Leveling Target, Improved.....	125
Linear Measurements in the Field.....	33
Linear Measurements in the Office.....	53
Logarithmic Spiral Curve, The.....	44, 129, 152
Logarithms.....	11, 22
MAGNETIC Pole, To find.....	169
Metric System.....	121, 139
NEW Books.....	7, 48, 119, 167
ODOMETER, The.....	95
PANTOGRAPH, The.....	77
Paper, Blue Process or Heliographic.....	60
Paper, Universal Drawing.....	6
"Paragon" Drawing Instruments.....	6
"Paragon" Scales.....	54
Passometer, The.....	95
Pedometer, The.....	94
Planimeter, The Polar.....	145, 162, 184
Position Finding.....	88
Principle of the Slide Rule, The one great.....	15
Prognostics, Weather.....	112
Proportion.....	22

Proportional Dividers.....	30, 46, 108
Pump Indicator, The.....	12
RATIO and Proportion.....	22
Readers, To our.....	I, 40, 120, 136
Relation of Drawing to General Education.....	176
Rollers for Targets.....	126
Round Writing.....	170
SAEGMULLER Solar Attachment.....	97
Scales, Paragon.....	54
Scientific Progress in 1891.....	126
Section Liner, Both's.....	189
Series of Numbers, and their application to Scientific Purposes.	
	9, 21, 37, 56, 72, 90, 107, 129, 152 177,
Sines and Tangents on the Slide Rule.....	74
Slide, The inverted.....	58
Slide Rule, The.....	37, 56, 72, 90
Slide Rule Computations, The accuracy of.....	124
Slide Rule, The "Duplex".....	63, 80
Slopes and Angles.....	90
Slope Stake Setter, A new.....	25
Solar Attachment, The Saegmuller.....	97
Speedy Calculators.	
Average Steam Pressure.....	17
Boucher Calculator, The.....	82
Charpentier Calculator, The.....	81
Logarithmic Spiral Curve, The.....	44
Polar Planimeter, The.....	145, 162, 184
Pump Indicator, The.....	11
Steam Pressure and H. P. Indicator.....	52
Thacher Calculating Instrument.....	65
Trigonometer, The.....	133
Universal Adding Machine.....	101
Webb's Adder.....	103
Spirograph, The.....	89
Stadia Calculations with the Slide Rule.....	91
Stadia Hairs.....	86
Stadia Slide Rule, The.....	92
Steam Pressure and H. P. Indicator.....	52
Steam Pressure, Average, how to calculate.....	17, 44
Steel Tape for Measuring Distances and Circumferences.....	179
TABLES:—Gradienter.....	156, 172, 180
Paces converted into Miles.....	96

Tapes, Steel.....	34
Thacher Calculating Instrument.....	65
To our Patrons and Readers.....	I, 40, 120, 136
Transit, The.....	3
Bubble Measurements.....	104
Centre Clamps.....	19
Centres, The.....	4
Compass.....	49
Eye piece prism.....	107
Gradienter Attachment.....	115, 141, 156
Horizontal Limb, The.....	20, 36
Leveling Plates.....	7
Standards, The.....	50
Stadia Hairs.....	56
Telescopes.....	51, 68
Variation Plate.....	50
Verniers, The.....	35
Vertical Limb, The.....	106
Trigonometer, The.....	133
UNIVERSAL Adding Machine.....	101
"Universal" Drawing Paper.....	6
VANISHING Points in Perspective Drawing...	98
Verniers ...	28
WARD'S Engineer's Tape.....	161
Weather Prognostics.....	112
Webb's Adder.....	103
Whetstones.....	87



COMPLETE COPIES of the first Volume of "THE COMPASS" can be had, bound in cloth, for \$1.75 each, postage prepaid.



"COPYRIGHT, 1891, BY WILLIAM COX, NEW YORK."

**A Monthly Journal for Engineers, Surveyors, Architects, Draughtsmen
and Students.**

Vol. I.

AUGUST 1, 1891.

No. 1.

TO OUR PATRONS AND READERS.

WE ISSUE this, the first number of a new serial, venturing to believe that it will be found to fill a want. It will be our endeavour to give such information respecting the construction of Mathematical and Surveying Instruments, with the best modes of using them, new and improved methods of procedure, etc., as may both interest the Engineer, Surveyor, Draughtsman or Student, and be of practical value to him in the pursuance of his profession. The theories and principles relating to the above will also be examined, whilst new inventions in the same and kindred branches, whether domestic or foreign, will receive that attention to which their merits may entitle them.

No pains or expense will be spared to make this serial a valuable and necessary companion both in the field and in the office, and one which will be ever found to point to the true North of Progress and Advancement in those Arts and Sciences to whose study it is devoted.

It is proposed that each number shall, as far as may be practicable, contain articles treating of the following subjects:

1. A practical and descriptive one devoted to Instruments for outside or field work.
2. A similar one devoted to Instruments for office work.

3. An article treating theoretically of the principles which underlie the construction and use of such instruments.
4. Descriptions of novelties ; short references to materials and other objects of general use ; foreign information ; miscellaneous items of interest to Engineers, etc.

We trust that THE COMPASS may prove to be what its name indicates, and be found indispensable by all those who are engaged in the various branches of the Engineering profession.

We shall be very pleased to receive any information from our readers of a practical nature touching upon modes of procedure, experience in the field, etc., as also to answer, as far as in our power lies, enquiries referring to the many subjects embraced in our programme. Our wish is that this serial may be taken advantage of and used as a medium of communication between Engineers, Surveyors and others ; that it may be considered as common ground upon which thoughts, information and experiences may be exchanged, to the ultimate benefit of all engaged in this noble profession.



COMPASS VARIATIONS.

ENGINEERING NEWS in its number of June 13th gives a condensed report of an interesting paper recently read by Mr. GUY R. JOHNSON, Longdale, Va., at the Cleveland meeting of the American Institute of Mining Engineers, on "Methods of Working and Surveying the Mines of the Longdale Iron Co., Virginia." The mine is entered by four car levels, and these were surveyed with transit and level. Mr. Johnson, referring to the bearings noted in these levels, as indicated by the compass says:—

"Of course the presence of the iron rails used in the car levels renders the needle more or less unreliable. In this connection I would call attention to a somewhat curious experience in connection with the needle bearings. Whenever the work was carried on in a dry section of the mine the needle seemed but little affected by the presence of the rails ; but as soon as water was encountered in sufficient quantities to make the track muddy, it became totally unreliable, variations of 5° being not uncommon. I was greatly puzzled by this, and finally became convinced that the water and mud, by making a perfect connection between the rails, permitted a greater degree of polarization and consequently increased the effect upon the needle."

We shall be pleased to hear from any of our readers who have had similar experiences, and to know if they attributed these variations to a like cause.

ENGINEERING AND SURVEYING INSTRUMENTS.

THE SELECTION of his instruments is to the Engineer a matter of highest import. The chief points to be taken into consideration are :

- 1st. Simplicity in the construction and in the combination of the various parts, permitting a facile manipulation of the whole instrument and of its component members.
- 2d. Lightness combined with strength and rigidity, to prevent tremor or unsteadiness, and also as far as possible damage or breakage in case of a fall or other shock.
- 3d. Perfect adjustments and accurate graduations, with facility in the noting of same.

Complicated parts, combinations and modes of use, however intrinsically meritorious they may be, should be especially avoided, as they cause unnecessary labor and are a frequent source of error.

Special attention should be paid to the metals employed, only such being allowed which are least subject to unequal expansion and contraction by reason of variations of temperature. Rolled or drawn metals should, wherever possible, be substituted for castings, as they offer more resistance and are also more solid.

We purpose in the course of these articles reviewing the various instruments used by the Engineer, Surveyor and others, and to indicate such points in each of them which we believe to be worthy of careful study, or which present new and important features hitherto generally unknown. We commence therefore with

THE PLAIN TRANSIT.

A TRANSIT may be considered to consist of two principal parts :

- 1st. The Centres with the Top or Compass Plate, the graduated Horizontal Limb, the Leveling Plates, and their various attachments;
- 2d. The Standards with the Telescope and its different attachments.

As no instrument which is badly centred can do good service, we shall direct our attention in the first place to this important point. The accompanying Fig. 1 illustrates the most recent combination and con-

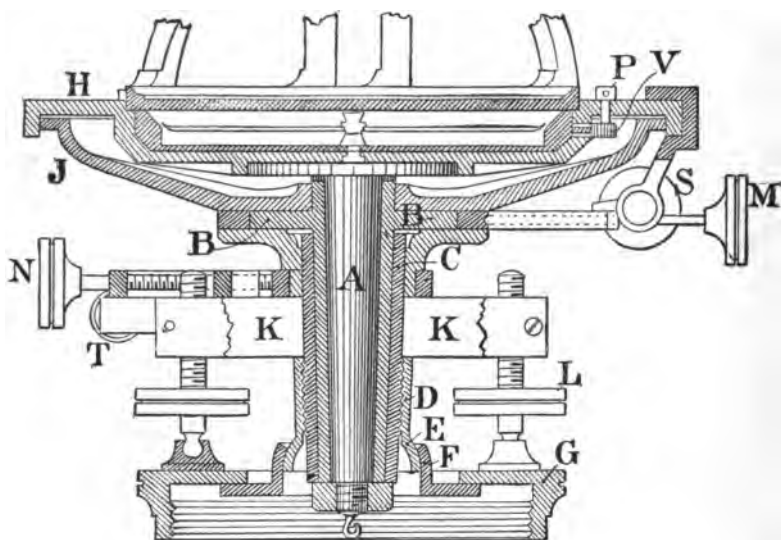


Fig. 1.

struction of centres. It will be seen that they are triple compound, and long enough to give stability while allowing the whole instrument to be brought down as close as possible to the tripod head. The inner centre or spindle *A* is of hard wrought brass and the others are made of two kinds of special anti-friction metal, so that they may move upon each other with the least possible wear, and still allow the instrument to revolve on its axis freely and smoothly, yet without any play. The top plate *H* rests on the upper surface of the spindle *A* and serves, as is usual, to support the telescope standards and also to contain the compass-box.

Around the spindle *A* is a sleeve *B*, called the "outer centre," which carries the lower plate with the horizontal limb *J*. This sleeve is nicely finished and adjusted and revolves concentrically around

the spindle. Another sleeve *C* revolves likewise around the outer centre, and to it are joined the patent leveling arms, which replace the ordinary leveling plate. To this sleeve is fixed a false sleeve *D* with the half ball *E*, the latter being encircled by the socket *F* which, with the bottom or lower leveling plate *G*, forms the rocking and shifting centre.

All these centres are made to fit into each other with the greatest accuracy, each one being concentric with the others, and all with the inner spindle, so that the levels, if adjusted to one of them, will maintain an accurate adjustment when turned round upon another one.

As it is of the greatest importance that the centres should be well protected, so that in case of a fall, shock or other rough usage, they may not be strained or otherwise affected or injured, an original patented construction of the lower or leveling part is adopted, as shown in the figure. The half ball joint *E* is not attached, as is usual, directly to the outer sleeve *C*, but forms part of a false sleeve *D*, which is screwed to the outer one to which the leveling arms are joined. There is between this false sleeve and the outer sleeve *C* a small annular space so that the half ball joint on receiving a blow would spring or bend, and consequently allow the instrument to endure such rough usage without injury to the inner centres.

The ordinary leveling plate is replaced, as already stated, by four peculiarly formed arms, of light but strong construction, as shown at *K* in

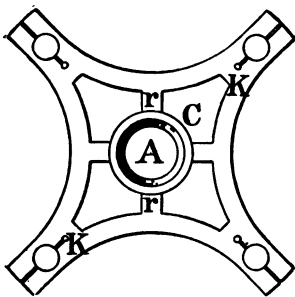


Fig. 2.

Fig. 2. These arms are joined to the sleeve *C* at the points *r* which are not radially in a line with the several arms themselves, but are within the spaces between them. By this means should an arm be bent by a blow, or strained by the leveling screws *L*, the distribution of the points of connection with the sleeve *C* would prevent it from being distorted and the delicate centers *A* and *B* from being injured.

Another important advantage of this substitution of arms for a solid plate is that it gives more room for the fingers to manipulate the leveling and other screws. In the field and in cold weather this point will undoubtedly have considerable weight, as affecting the comfort and convenience of the operator.

The threaded holes which receive the leveling screws are split and can be adjusted by means of a screw, which allows the friction to be made uniform under all conditions of wear. The dust collects in these slots

whence it may be easily and efficiently removed without in any way injuring the thread of the screws.

The usual horizontal movement of the instrument on the bottom plate (called a shifting centre) is obtained by giving to the socket *F* liberty to adjust itself in all directions horizontally to the fixed bottom plate *G*, thus enabling the transit to be immediately brought exactly over a given point on the ground, after the tripod has been approximately set.

(To be continued.)

THE BEST DRAWING INSTRUMENTS always possess grace and symmetry in their parts, their surfaces are perfectly even and straight, and their angles are sharp and well defined. The "finishing" is done by hand and leaves a fine grain, which is at right angles with the length of the instrument. As hand labor enters very largely into the cost of such instruments, it naturally follows that none but the best materials are used in their manufacture, as German Silver and the finest English Steel, the former being invariably rolled plate metal, and the latter hand-forged, castings being used only for inferior instruments.

PARAGON Instruments (with Keuffel & Esser Co.'s firm name or initials) possess all these qualities, and give undoubted satisfaction. That such is the case, is abundantly proved by the number of imitations of them, which have been made.

IT IS OF THE GREATEST IMPORTANCE for the production of good work, that both tools and material be of irreproachable quality. In nothing is this perhaps more necessary than in the case of drawing materials. Although the old adage says "a bad workman complains of his tools," yet the antithesis is equally true, for without good tools and materials the best workman is unable to produce good work. This applies also in a special sense to students, and it will be found to be a mistake to supply them with cheap paper, as with such, their drawings, however carefully executed, will never look finished, so that they are apt to become indifferent and callous and cease to put forth their best efforts.

UNIVERSAL DRAWING PAPER, as supplied by the above firm, is specially suitable for Colleges and Schools; it is made of pure stock, is free from adulterations and very carefully sized. The surface is slightly grained and is suitable for work in Ink, Color, Pencil or Crayon, while its erasing properties are perfect. These various qualities render it specially adapted to preliminary drawings and, as stated, for school purposes. It may be had in either sheets or rolls.

NEW BOOKS.

PHOTOGRAPHY APPLIED TO SURVEYING, by Lieut. Henry A. Reed, U. S. Army, is the title of a most interesting book, in which the author endeavors to prove (and very successfully we think) how the application of this art to surveying shows a saving of time and labor that cannot be attained by any other known means, and how, as in ordinary surveying, the results obtained exhibit an accuracy that is directly proportioned to the quality of the instruments employed, and to the care exercised in the field-work. The book is handsomely got up and the context suitably illustrated. It is published by John Wiley and Sons, New York.

THE POLAR PLANIMETER. A small Manual has just been published by Keuffel & Esser Co., on the above, having special reference to that latest form of this useful instrument in which the arm with the Tracer is graduated, and its length can be adjusted so that the Planimeter may be used to obtain the area of a drawing made to any scale. Besides instructions for its use, a complete table of approximate settings of the graduated arm is given, which will materially assist in finding the exact setting for more than fifty different scales. 8vo., pp. 20. Price 20 cents.

AN EXPLANATION of the Principles and Operation of the Mannheim Slide Rule, by C. W. Crockett, Assistant Professor of Mathematics and Astronomy, Rensselaer Polytechnic Institute. 8 vo., pp. 26.

This manual is written primarily for the use of the students of the Institute, and is consequently a theoretical and logarithmical exposition of the principles upon which the Slide Rule is constructed, and the way it is to be used. For those whose labors are of a more practical nature, or who have not the necessary leisure to devote to such theoretic studies, we feel sure this book, although admirable in its conception and execution, would speedily dispel any desire they might have to become acquainted with so useful and valuable an instrument. We believe that our own recently published treatise *) will be found much simpler and more practical, and yet give as clear an idea of the principles referred to in the work under consideration.

The "Suggested Modification" given on the last page is by no means new to us, as we have long had it under consideration, and shall ere long submit to our readers a new and patented Slide Rule which will permit of all the problems named being solved in the simplest manner possible with *one setting*. Our Rule will not have the bulky dimensions which the suggested modification would necessitate.

*) The Slide Rule, with tables of Equivalents and Methods of working out Mechanical and other Formulæ, by Wm. Cox. 8 vo., pp. 30. Price 50 cts. Published by Keuffel & Esser Co.

THE COMPASS.

A Monthly Journal published the first of every month, at 127 Fulton Street, New York City.

WILLIAM COX, - - - - -	Editor.
KEUFFEL & ESSER CO., - - - - -	Publishers.

SUBSCRIPTION \$2.00 per year, in advance, postage paid. Single Copies, 20 Cents each.
CORRESPONDENCE should be addressed to the Editor of *THE COMPASS*, 127 Fulton Street, New York City.

All such bearing upon the topics to which the Journal is devoted, will be thankfully received and acknowledged with pleasure.

CONTENTS.

	PAGE.
To our Patrons and Readers, - - - - -	I
Compass Variations, - - - - -	2
Engineering and Surveying Instruments, - - - - -	3
Drawing Instruments, - - - - -	6
Drawing Paper, - - - - -	6
New Books, - - - - -	7
Can Aluminum be advantageously employed in the Construction of Geodetic Instruments? - - - - -	8
Series of Numbers with Examples of their Practical Application to Scientific Purposes - - - - -	9
Speedy Calculators, - - - - -	11
The Centrolinead, - - - - -	13
A New Extension Tripod, - - - - -	16

CAN ALUMINUM BE ADVANTAGEOUSLY EMPLOYED IN THE CONSTRUCTION OF GEODETIC INSTRUMENTS?

Two *WIDELY* divergent impressions appear to prevail as to the use of Aluminum:—one a Utopian one, held by many people who would have us believe that this metal is eventually to supersede all others. Another opinion, the reverse of the former, is that its general adoption is relegated to the Greek Calends. Being ourselves neither optimist nor pessimist, we believe that in a few cases (but in a very few only) it may be used to advantage; but with our present limited knowledge of its many and valuable qualities we do not consider it a suitable metal to enter largely into the construction of instruments of precision. In its pure state, it is one of the most ductile and malleable of metals, but alloyed with 10 per cent of copper, it becomes not only harder but also brittle, and when alloyed with 20 to 30 per cent of copper, its brittleness can almost be compared with that of glass, so that an indiscriminate use of Aluminum in the construction of Surveying Instruments would be found to lead to disastrous results. In any such its adoption should be limited to non-revolving parts, as the friction and wear they would undergo would be so

great as to necessitate frequent renewals. All the finer bearings of such an instrument would also have to be made of some hard antifriction metal, and this oft recurring combination of metals would certainly be found to have a natural tendency to weaken such parts as well as to cause unequal expansion and contraction and consequent deranged adjustments.

We are aware that where an instrument has to be transported long distances over uneven ground, its weight is a matter of no small consideration, but even this must not be unduly sacrificed to stability. A certain amount of dead weight will always be necessary either in the instrument or in the tripod to secure that degree of steadiness which will enable the instrument to resist exposure to the pressure of the wind and consequent tremor and vibrations which affect materially a sensitive level or a telescope of high power.

It should not be forgotten that Aluminum is comparatively new, but its manufacturers are quickly learning how to treat it and how to secure those various qualities of rigidity, strength, hardness, ductility, luster etc. We shall continue to watch closely the progress made, and wherever its adoption is fully warranted, shall not hesitate to recommend that advantage be taken of the superior qualities which it may offer. Meanwhile we may state that Keuffel & Esser Co. have already made instruments of Aluminum and can show them to anyone wishing to judge of the suitability or otherwise of this metal; they are also prepared to make use of it to any extent that may be desired, but without offering any guarantee whatever as to the results or the satisfaction that such instruments would give.



*SERIES OF NUMBERS WITH EXAMPLES OF THEIR
PRACTICAL APPLICATION TO SCIENTIFIC
PURPOSES.*

1. QUANTITY is anything which may be increased, diminished or measured, or respecting which it may be asked: "How much or How many?"
2. NUMBERS are the symbols adopted whereby the values of quantities are expressed.
3. FIGURES are the arbitrary signs employed to represent numbers.
4. Quantities may be *increased* by addition and multiplication, and *diminished* by subtraction and division.
5. The increase or decrease of quantities by addition and subtraction may be considered as being effected by means of a series of numbers in what is termed Arithmetical Progression.
6. The increase or decrease of quantities by multiplication and division may be considered as being effected by means of a series of numbers in what is termed Geometrical Progression.

7. These two series of numbers, representing two distinctive modes in which the values of quantities vary, possess very remarkable properties in regard to each other, which properties underlie almost the whole of mathematical science.
8. Every mathematical instrument, every machine, every mechanical or other structure, owes its usefulness to the mathematical principles, upon which its construction depends, and these, as stated, may all be very largely traced to the properties of the two series of numbers already named, whether taken singly or conjointly.

We will first of all examine the properties of these two series of numbers and then see how they are applied to some of the many instruments, which are such valuable aids to the Engineer and Surveyor.

A series of numbers is said to be in *Arithmetical Progression* (*A. P.*) when they continually increase or decrease by the addition or subtraction of a given uniform quantity, as 1, 2, 3, 4, etc., or 12, 9, 6, 3, etc., where the common *difference* between any two consecutive terms of the series is 1 and 3 respectively, the one being an increasing and the other a decreasing series.

A series of numbers is said to be in *Geometrical Progression* (*G. P.*) when each term is derived from the one immediately preceding it by multiplying or dividing it by a given constant quantity as 1, 2, 4, 8, etc., or 1, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, etc., where the common *ratio* of any one term to the next preceding one is 2 and $\frac{1}{2}$ respectively; the one being an increasing and the other a decreasing series, and the ratio in the latter being the fraction $\frac{1}{2}$, if taken as a multiplier, or the whole number 2, if considered as a divisor.

Let us now place two such series over each other and examine the peculiar properties which they possess when taken conjointly, thus:

<i>A. P.</i> —0	1	2	3	4	5	6	7	8	9	10
<i>G. P.</i> —1	2	4	8	16	32	64	128	256	512	1024

Here the first series is one in *A. P.*, the common difference being *one*, while the second series is one in *G. P.*, the common ratio being 2.

We here note

1st—If we add together any two numbers of the series in *A. P.*, the number of the series in *G. P.* corresponding with their *sum* will be equal to the *product* of the two corresponding numbers in the *G.* series; thus 2+3 of the *A.* series = 5, and the number corresponding in the *G.* series with 5 is 32, and this is the product of 4 and 8, which correspond with 2 and 3 in the *A.* series.

2d—If we subtract any number of the *A.* series from any other number of the same series, the number of the *G.* series corresponding with

their *difference* will be equal to the *quotient* of the two corresponding numbers in the *G.* series; thus $7-4$ of the *A.* series $= 3$, and the number corresponding in the *G.* series with 3 is 8, which is the quotient of $128 \div 16$, these numbers corresponding with 7 and 4 of the *A.* series.

3d.—If we multiply any number of the *A.* series by 2, 3 or any other number, the number of the *G.* series corresponding with their *product* will be equal to the second, third or other *power* of the corresponding number in the *G.* series; thus 2×3 of the *A.* series $= 6$, and the number corresponding in the *G.* series with 6 is 64, which is the third power or cube of 4, this number corresponding with 2 of the *A.* series.

4th—If we divide any number of the *A.* series by 2, 3 or any other number, the number of the *G.* series corresponding with their *quotient* will be equal to the second, third or other *root* of the corresponding number of the *G.* series; thus $8 \div 4$ of the *A.* series $= 2$, and the number corresponding in the *G.* series with 2 is 4, which is the fourth root of 256, this latter corresponding with 8 of the *A.* series.

These properties belong equally to any other series of numbers taken conjointly in *A.* and *G.* Progression, as for instance

0	1	2	3	4	5	6	etc.
1	10	100	1,000	10,000	100,000,	1,000,000 etc.	

When two series of numbers are thus taken together, the numbers of the series in *A. P.* are said to be the *logarithms* of the numbers composing the series in *G. P.*, and if the logarithms of the intermediate numbers of the *G.* series be ascertained, and the whole tabulated (making what is termed a table of logarithms) we should be enabled to perform with them in the simplest manner possible, the most complicated arithmetical calculations.

(To be continued.)

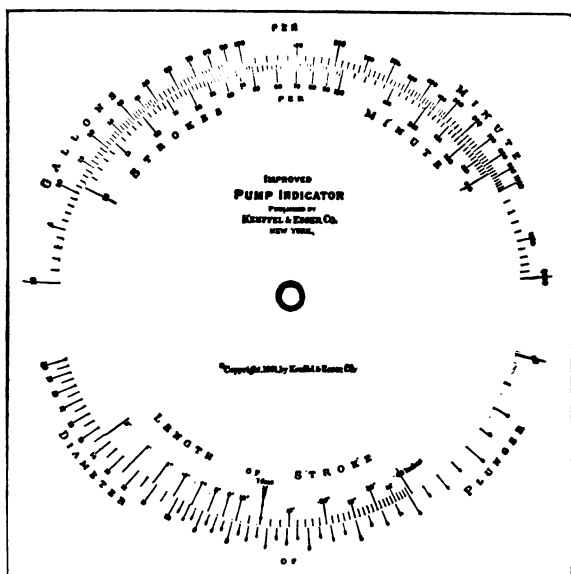
SPEEDY CALCULATORS.

THERE ARE in the Engineer's practice many formulæ whose solution is repeatedly required. To facilitate this labor he has often recourse to tables, but these are frequently incomplete or only applicable to certain cases. Any means therefore, whereby he may be enabled to ascertain quickly and accurately the Delivery of a Pump, the Mean Pressure of Steam in an Engine Cylinder with any cut-off, the Horse Power of a Steam Engine, the Horse Power of a Fall of Water or of a Turbine, etc., will be, we are sure, heartily welcomed. Such are the series of Indicators which we propose to introduce to our readers. They are published by Keuffel & Esser Co., are well got up and may be relied upon for their accuracy. On this account,

and also because their construction is based upon those mathematical principles to which we have alluded in our article on "Series of Numbers and their practical application to Scientific Purposes," greater dependence may be placed on the results obtained by their means than on those arrived at by the ordinary methods of arithmetical computation. The manner of using them is also so simple that a very tyro, unacquainted with even the common rules of arithmetic, may accurately solve the problems to which they are applicable. We commence with the

IMPROVED PUMP INDICATOR.

This indicator consists of a square foundation plate of wood or Bristol Board in the centre of which revolves a circular disk about 8 inches in diameter as shown in the figure. The plate and the disk are



suitably graduated with scales of the "Diameter of Plunger,"—"Gallons delivered per minute,"—"Length of Stroke,"—and "Number of Strokes per minute," the two first being on the Indicator and the other two on the disk. The Pump Indicator gives at sight either of the two following results:—

- 1st. The delivery in Gallons per minute of a Piston Pump, for any diameter of plunger, length of stroke and number of strokes per minute, and
- 2nd. The diameter of plunger, length of stroke and number of strokes per minute required to deliver a given number of gallons of water per minute.

To obtain the first result, all that is necessary is to set the length of stroke on the disk against the diameter of the plunger, when the quantity of water delivered will be found corresponding with the given number of strokes. To find the second result, the operation is reversed, only it must be noted that all coinciding diameters and lengths of stroke will deliver the quantity of water required; it remains but to choose the most suitable combination.

Calculations are frequently based upon a given piston speed instead of the length of stroke and number of strokes per minute. In this case 1 foot length of stroke (marked with an arrow) is set to the diameter of plunger, and the delivery read off opposite the number of strokes per minute which naturally now represent the piston speed in feet per minute, which can be easily reduced to any suitable number of strokes per minute of any desired length.

THE CENTROLINEAD.

IN THE DRAWING of an object represented in perspective, all parallel horizontal receding lines should converge towards and meet in a certain point called the vanishing point. This point is situated on the horizontal line or line of sight, and its distance either to the right or to the left of the object represented depends upon the position of the observer as related to the object viewed. This point is in many cases so distant that it cannot be located upon the drawing board, and consequently renders the task of producing the vanishing lines an inconvenient one. The Centrolinead is a very simple instrument designed to overcome this difficulty, as by its means radial lines converging towards a point however distant may be drawn without requiring greater surface to work upon than that occupied by the finished drawing.

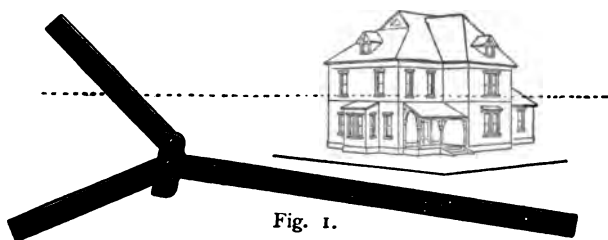


Fig. 1.

THE CENTROLINEAD consists, as shown in Fig. 1, of a long flat double-edged rule or blade to which two arms of equal length are jointed by thumb-screws in such a manner that they may be set and clamped at any required angle. The joints are so placed that one edge of the blade and the inner edge of each arm intersect each other in the head and thus form

the upper edge of the blade, all of which will converge towards and meet in the given vanishing point G , care being taken in moving the blade upwards or downwards that the arms always bear against the studs. The simple rule for obtaining the distance AE is as follows,—

Multiply the height of either of the studs from the horizontal line by itself, divide the product by the required distance of the vanishing point from the vertical line, and the quotient will be the distance of the centre of the head of the instrument from the vertical line ; that is

$$AE = \frac{AS \times AS}{AG}$$

In some cases it may be found easier to fix a convenient distance for AE , say 2 inches, and then ascertain the position of the studs. This may be done very easily by transposing the formula as follows :

$$AS = \sqrt{AG \times AE}$$

These methods of setting the Centrolinead will be found much quicker and more exact than the usual one of estimating and seeking by repeated trials the angle of the opening of the two arms. Care must always be taken that the two studs are placed equally distant from the horizontal line so that the angle SEA shall be equal to the angle S_1EA , otherwise the drawing will not be correct.

We append a few settings which will be found useful.

AG	AS	AE	AG	AS	AE
6 inches.	3 inches.	$1\frac{1}{2}$ inches.	24 inches.	6 inches.	$1\frac{1}{2}$ inches.
8 “	4 “	2 “	28 “	$7\frac{1}{2}$ “	2 “
10 “	5 “	$2\frac{1}{2}$ “	32 “	8 “	2 “
12 “	$4\frac{9}{16}$ “	2 “	36 “	$8\frac{1}{2}$ “	2 “
14 “	$5\frac{3}{8}$ “	2 “	40 “	$7\frac{1}{4}$ “	$1\frac{1}{2}$ “
16 “	6 “	$2\frac{1}{4}$ “	44 “	$8\frac{1}{4}$ “	$1\frac{1}{2}$ “
18 “	6 “	2 “	48 “	8 “	$1\frac{1}{2}$ “
20 “	5 “	$1\frac{1}{4}$ “	52 “	8 “	$1\frac{1}{4}$ “

THE ONE GREAT PRINCIPLE which underlies the construction and use of the SLIDE RULE is that, place the slide as we will, all the coinciding numbers of the slide and the rule form *equal ratios*. As multiplication and division are always reducible to a simple proportion, (which consists of two equal ratios) these arithmetical rules are worked out by setting the slide to the ratio indicated by the terms of the problem. Once this idea firmly grasped, the various modes of using the Slide Rule are self-apparent.

A NEW EXTENSION TRIPOD.



"Copyright, 1891, by Keuffel & Esser Co."

A LIGHT BUT FIRM Extension Tripod is considered by the Engineer and Surveyor to be a desideratum. The accompanying figure shows the most recent form brought out and patented by Keuffel & Esser Co. It combines rigidity with lightness; its manipulation is easy and effective, and its construction such, that the sliding leg can neither wear loose nor bind, but will always move smoothly. The special clamps used render it as steady, when the legs are fully drawn out, as any solid-legged tripod. The head is very firm, wing fittings being used instead of the tenon joint of the common tripod. It is adjustable to any height between 30 and 57 inches, and the weight of the ordinary model is 10 lbs. 7 oz., and of the light model 9 lbs. Whilst being as strong as any other Extension Tripod, it is less bulky and more portable.

THE FORMULA for obtaining the delivery of a piston pump is

$$G = D^2 \times S \times N \times .0034,$$

where G = Delivery in U. S. gallons per minute,

D = Diameter of plunger in inches,

S = Length of stroke in inches,

N = Number of effective strokes per minute.

If the delivery be required in cubic feet, the constant .0004545 must be used instead of .0034, or else the formula

$$C. ft. = \frac{D^2 \times S \times N}{2200}.$$

We give this formula because we have met with much misconception of the subject and consequent erroneous formulæ.



"COPYRIGHT, 1891, BY WILLIAM COX, NEW YORK."

**A Monthly Journal for Engineers, Surveyors, Architects, Draughtsmen
and Students.**

Vol. I.

SEPTEMBER 1, 1891.

No. 2.

SPEEDY CALCULATORS.

A FORMULA which Mechanical Engineers and others have frequently to work out, is that for calculating the mean effective pressure of steam in an engine cylinder, when the initial steam pressure and the point of cut-off are known. The formula is $M. E. P. = P \frac{1 + H}{R}$, in which

M. E. P. = Mean effective pressure of the steam during the whole stroke in lbs. per sq. in., including atmosphere.

P. = Initial pressure of steam in lbs. per sq. in., including atmosphere.

R. = Ratio of expansion = $\frac{L}{l}$.

L. = Length of stroke in inches.

l. = Distance travelled by the piston before the steam is cut off.

H. = Hyperbolic Logarithm of *R*.

There are various ways by which the calculation of this formula may be facilitated, thereby doing away with the necessity of referring to a table of logarithms. The simplest is by means of Gauge Points, as given in the accompanying table, which may be used for ordinary

arithmetical computation, or with the Slide Rule, for which they are specially suitable.

Portion of stroke at which steam is cut off.	Initial G. P.	Average G. P.	Portion of stroke at which steam is cut off.	Initial G. P.	Average G. P.
$\frac{7}{8}$	250	248	$\frac{6}{10}$	167	151
$\frac{3}{4}$	55	53	$\frac{4}{10}$	214	164
$\frac{5}{8}$	37	34	$\frac{3}{10}$	3	2
$\frac{1}{2}$	13	11	$\frac{2}{10}$	23	12
$\frac{3}{8}$	31	23	$\frac{1}{10}$	100	33
$\frac{1}{4}$	57	34	$\frac{5}{8}$..	68	67
$\frac{1}{8}$	13	5	$\frac{4}{8}$..	16	15
$\frac{9}{10}$..	200	199	$\frac{3}{8}$..	10	7
$\frac{8}{10}$..	139	136	$\frac{1}{8}$..	43	20
$\frac{7}{10}$..	139	132			

EXAMPLE.—Given an initial pressure of 48 lbs. per sq. in., with the steam cut off at two-thirds of the stroke:—What is the average or mean effective pressure for the whole stroke?

$$M. E. P. = \frac{48 \times A. G. P. \text{ for } \frac{2}{3} \text{ cut-off}}{I. G. P. \text{ for } \frac{2}{3} \text{ cut-off}} = \frac{48 \times 15}{16} = 45 \text{ lbs.}$$

For the Slide Rule, we place the *I. G. P.* for the given cut-off on scale *C* of the slide, so that it shall coincide with the *A. G. P.* on scale *D* of the rule; then with the slide in this position, we have a series of ratios representing the initial and average pressures for the given cut-off, so that any initial pressure being found on scale *C* of the slide, its corresponding average pressure is found coinciding with it on scale *D* of the rule. We demonstrate this in the following diagrammatical form:

$$\begin{array}{l} C \parallel \text{Set } I. G. P. \text{ for given cut-off} \mid \text{Under initial pressure,} \\ D \parallel \text{To } A. G. P. \text{ for given cut off} \mid \text{Find average pressure,} \end{array}$$

thus

$$\begin{array}{l} C \parallel \text{Set } I. G. P. 16 \mid \text{Under 48 lbs.} \\ D \parallel \text{To } A. G. P. 15 \mid \text{Find 45 lbs. average pressure.} \end{array}$$

This demonstration with the given Gauge Points is applicable to the Mannheim Slide Rule, in which the lower slide scale and the lower rule scale are graduated exactly alike from 1 to 10.

The mean effective pressure of steam may be also very easily obtained by means of a Logarithmic spiral curve, and also by mere inspection with the Improved Average Steam Pressure and H. P. Indicator, which we shall describe in a future number.

(To be continued.)

ENGINEERING AND SURVEYING INSTRUMENTS.

(Continued).

THE PLAIN TRANSIT.

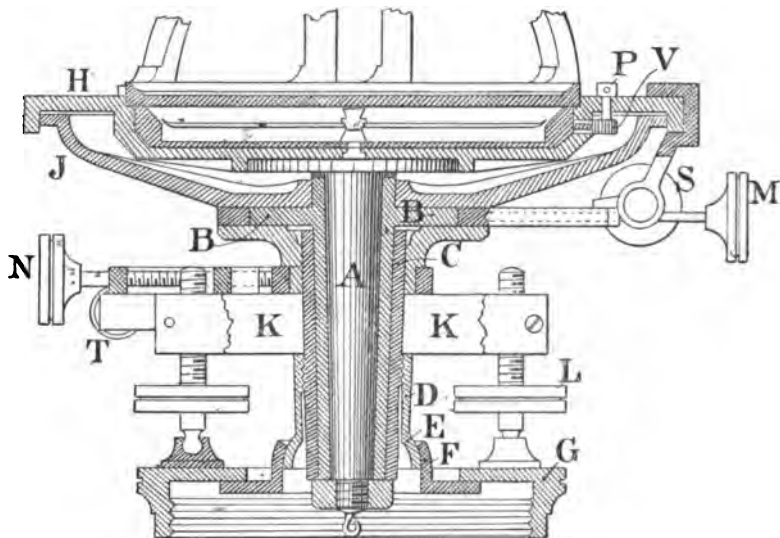


Fig. 1.

WE SHOWED in our last number that the several centres or sleeves of the Transit are made to revolve concentrically within each other and around the common central spindle *A*. As it is necessary that this liberty of motion should at times be arrested, two segment clamps are provided, which bind the centres absolutely and without in any wise injuring them.

The lower clamp shown at *N* in Fig. 1 serves to lock the outer centre *B* to the outer sleeve *C* with its leveling arms, so that the horizontal limb with its graduated circle may be held at will in any desired position as regards the fixed foundation of the instrument and the tripod, while the top plate with the compass and telescope may be turned round as required.

The upper clamp *M* locks together the inner centre or spindle *A* and the outer centre *B*, thus holding together the horizontal limb and the upper plate; consequently when both clamps are screwed up, all the revolving parts of the instrument are bound rigidly together. (This should always be done when the Transit is put away in its box, or when carrying it on its tripod.) If the upper clamp be screwed up and the lower one unscrewed, then both the upper plate and the horizontal limb can be turned round together at the same time.

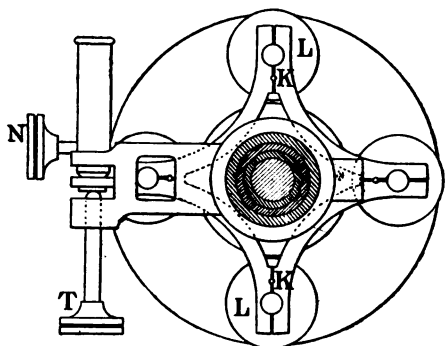


Fig. 2.

The clamps are provided with micrometer tangent or slow-motion screws *S* and *T*, permitting of a very fine adjustment of either or both plates, when they have been previously clamped by means of the clamp screws *M* and *N*; these tangent screws are provided with opposing or compensating springs to avoid lost motion. The screws themselves are made of German

silver, which is almost as hard as steel and permits of a very sharp and durable thread being cut in them.

The figures show how each clamp screw with its corresponding tangent screw is so placed that it is easily accessible when one hand is engaged with the telescope or otherwise employed, and we feel sure that this convenient arrangement, superseding the old and complicated one of two opposing screws needs but to be known in order to be appreciated.

When a Transit is going to be used, the first thing to be done, after setting it up firmly and bringing the plumb-bob exactly over the desired point on the ground by means of the shifting centre, is to level the upper plates and then clamp them securely.* This operation is performed by means of the four leveling screws *L*. The leveling arms *K* and the bottom plate *G* should be first set firmly apart by means of two *adjoining* screws, and the small levels brought in line with the leveling arms, after which the instrument is leveled by means of either or both of the two *opposing* pairs of screws. The Transit is raised on the side of the right hand screw of either pair by turning both corresponding screws *inwards*, and raised on the side of the left hand screw by turning both corresponding screws *outwards*. When it is required to do very fine work with very great accuracy in the settings it is usual to have three leveling screws instead of four. This arrangement will be referred to later on.

Having thus described the centres with their attachments for leveling and adjusting, we now turn our attention to the two upper revolving plates.

The lower plate *J* is a substantial casting, to whose upper surface is firmly riveted and soldered the horizontal limb which is made of rolled metal as it, being harder and more uniform than a casting, admits of better and more distinct graduations being made upon its surface, and these

* NOTE. The plumb-bob is suspended from the central spindle *A* and not from the tripod head, so as to insure the plumb line passing through the central vertical axis of the Transit under all positions of the tripod's legs.

when well silvered have the advantage of those on pure silver that they will not tarnish as quickly; the graduations may be had, however, when it is preferred, on solid silver.

The graduations of the horizontal limb are usually made to half degrees, reading by means of the vernier, to single minutes; or to 20 minutes, reading with the vernier to 30 seconds, and in special cases they may be had to read to 10 seconds.

(*To be continued.*)

SERIES OF NUMBERS WITH EXAMPLES OF THEIR PRACTICAL APPLICATION TO SCIENTIFIC PURPOSES.

(*Continued.*)

WE PURPOSE NOW examining a few other properties of the two kinds of series of numbers described in our last.

1st.—If any three consecutive terms of a series be taken together, the middle term is the *mean* of the two extreme terms, thus, if we take the three terms 4, 5 and 6 of a series in *A. P.*, then 5 is the *Arithmetical Mean* between 4 and 6, seeing that the difference between 4 and 5 is the same as between 5 and 6, whence the *A. M.* is half the sum of the extremes, as $\frac{4+6}{2} = 5$; and if we take the numbers 8, 16 and 32 of a series in *G. P.*, then 16 is the *Geometrical Mean* between 8 and 32, seeing that the common ratio of 16 to 8 is the same as that of 32 to 16, namely 2, whence we see that the *G. M.* is the square root of the product of the extremes, thus

$$\sqrt{8 \times 32} = \sqrt{256} = 16.$$

2d.—We may in like manner obtain the Arithmetical and Geometrical Means of two consecutive terms of a series; thus the *A. M.* between 1 and 2 is equal to $\frac{1+2}{2} = 1.5$; and the *G. M.* between 10 and 100 is equal to $\sqrt{10 \times 100} = \sqrt{1000} = 31.62..$ By continuing this process, we may obtain an infinite number of Arithmetical Means corresponding to a similar number of Geometrical Means, thus enabling us to fill out in a great measure our table of logarithms, as:

<i>A. P.</i>	0	.25	.5	.75	1	1.25	1.5	1.75	2	etc.
<i>G. P.</i>	1	1.77..	3.16..	5.62..	10.0	17.7..	31.6..	56.2..	100.0	etc.

3d.—By multiplying and dividing the numbers of the *G.* series, and adding and subtracting the corresponding numbers of the *A.* series; as

also by extracting the powers and roots of the *G.* series, and multiplying and dividing the corresponding numbers of the *A.* series by the given exponent or index, we may obtain a further considerable number of logarithms, so that if we have the logarithms of a few prime numbers, we may easily find those of any quantity of composite numbers, thus:

$$\begin{aligned} \log \text{ of } 10 &= 1 & \text{or } \log \text{ of } 5.62 &= .75 \\ \log \text{ of } 31.6 &= 1.5 & \log \text{ of } 31.6 &= 1.5, \text{ therefore} \\ \log \text{ of } 316 &= 2.5 & \text{and } \log \text{ of } 177.8 &= 2.25 \\ & & \text{or again } \log \text{ of } 1.77.. &= .25 \\ & & \log \text{ of } 1.77^3.. &= .25 \times 3 \\ & & \text{whence } \log \text{ of } 5.62.. &= .75. \end{aligned}$$

4th.—In comparing the value of two quantities or numbers, we may proceed by one of two methods: either by ascertaining how many units must be added to the one or subtracted from the other, in order that their value may be equal, as 9 and 16, where 7 must be added to the one or subtracted from the other, to make them equal, thus $9 + 7 = 16$, or $16 - 7 = 9$; or we may ascertain how many times one of the quantities contains or is contained in the other, as 4 and 12, where 4 is contained 3 times in 12, or 12 contains 4 three times, which is equivalent to $4 \times 3 = 12$, or $12 \div 3 = 4$. The relation of the one number or quantity to the other is in the first case termed their *difference*, and is expressed by the sign $\sim$, thus $a \sim b$ means the difference between a and b , it not being known which is the greater; and the relation of one number or quantity to the other in the second case is termed the *ratio*, and is usually expressed by the sign $:$, thus $4 : 12$ means the ratio of 4 to 12, or the part which 12 is of 4, namely 3. The ratio may also be expressed as a fraction as $\frac{12}{4} = 3$. These two methods of comparison answer to the two different kinds of progression of series of numbers.

5th.—When we have four numbers, in which the ratio of the first to the second is the same as the ratio of the third to the fourth, these four numbers form a *proportion*, or an equality of ratios, and the different numbers are designated as the first, second, etc. terms. The usual method of expressing a proportion, is by means of the signs $::$ or $=$, as $2 : 4 :: 3 : 6$ or $4 : 9 = 6 : 13.5$, where the ratio of 4 to 9 is the same as or is equal to the ratio of 6 to 13.5. In a series of numbers in Geometrical Progression, any four consecutive terms form a proportion, as $2 : 4 = 8 : 16$ or $32 : 64 = 128 : 256$.

6th.—These proportions may be infinitely varied, provided that the relationship or correspondence of the terms of the first ratio be equally observed in the terms of the second ratio; thus, if *consecutive* terms of the

THE COMPASS.

A Monthly Journal published the first of every month, at 127 Fulton Street, New York City.

WILLIAM COX,	-	-	-	-	-	-	-	-	Editor.
KEUFFEL & ESSER CO.,	-	-	-	-	-	-	-	-	Publishers.

SUBSCRIPTION \$2.00 per year, in advance, postage paid. Single Copies, 20 Cents each.
CORRESPONDENCE should be addressed to the Editor of *THE COMPASS*, 127 Fulton Street, New York City.

All such bearing upon the topics to which the Journal is devoted, will be thankfully received and acknowledged with pleasure.

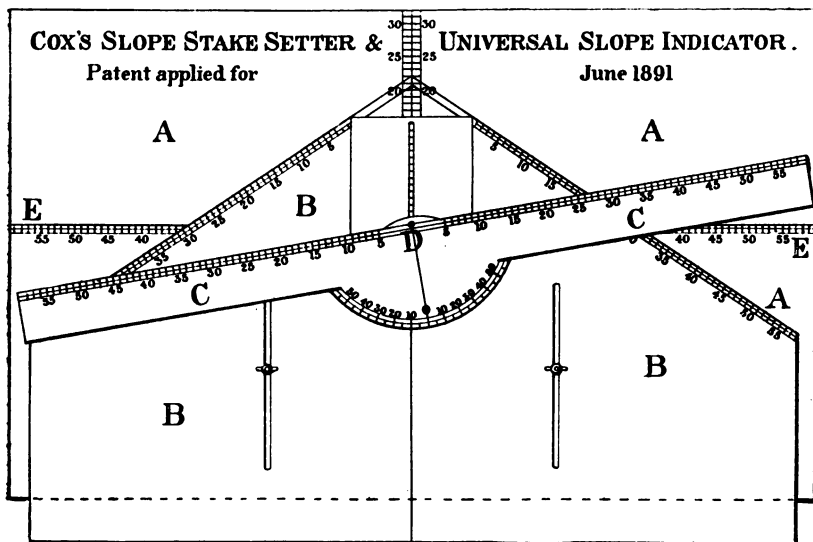
CONTENTS.

	PAGE.
Speedy Calculators,	17
Engineering and Surveying Instruments,	19
Series of Numbers with Examples of their Practical Application to Scientific Purposes	21
A new Slope Stake Setter and Universal Slope Indicator,	25
Verniers,	28
Proportional Dividers,	30

WHO DOES NOT REMEMBER with what veneration he in his young days regarded the honored stick of Chinese Ink, with its grotesque hieroglyphics? In these days of progress, even this useful article is becoming more and more a relic of the past, and its death knell may be said to have sounded. The hard stick, which requires such patient rubbing on the slab to produce a small amount of serviceable ink, has by degrees fallen into disfavor, and is very generally replaced by the liquid article; so also the hard cakes of color, after passing through the "moist" stage, have likewise, for the purpose of mechanical or architectural drawing, been very largely transformed into the liquid state, and to-day COLUMBIA INDELIBLE LIQUID INKS rank among the necessities of the drawing office

These drawing inks, in black and colors, being insoluble when dry, are perfectly indelible or water-proof, and lines drawn with them, although washed over with frequent brush tints, will neither blur nor be defaced. This quality will be found to be of special value when in the case of outdoor work, the drawing may be exposed to the inclemency of the weather. Nor must the brilliancy and permanency of the colors, as well as their fluidity, be overlooked, while the mode of putting them up in bottles provided with a patent ink filler, makes their use all that the most fastidiously clean could desire.

A NEW SLOPE STAKE SETTER AND UNIVERSAL SLOPE INDICATOR.



"Copyright, 1891, by William Cox."

Fig. 1.

THE ACCOMPANYING FIGURE represents a new time-saving contrivance (the invention of our editor) which will, we feel sure, be found of great use by all those engaged in railway work. It serves two special purposes:

Firstly.—By its means the exact point of intersection of the slope of an embankment or cutting with the natural surface of the ground, and consequently the position of the slope stakes, is immediately and accurately ascertained, and that without any calculations whatever.

Secondly.—The instrument gives instantly and also without any calculation, all the various dimensions of embankments or cuttings, with varying ground surfaces and side slope ratios, from which the area of the cross-section may be calculated in the simplest manner possible and in the shortest time.

THE INDICATOR consists of three flat pieces of wood, metal, Bristol board or other material, namely:

AA; the foundation plate with a central horizontal line and a central vertical line, both graduated to a convenient scale of feet. The point of intersection of these two lines represents the centre line

along the natural surface of the ground, whilst the centre height is measured upwards from the same on the vertical line.

BB; a vertical sliding-piece representing the cross section of an embankment or cutting. This piece is interchangeable, so that it may suit different slope ratios and widths of road-bed. The slopes are graduated to the same scale of feet, as is also a vertical line drawn downwards on each side of the road-bed, giving the height of each of its sides above the ground surface.

CC; a straight scale revolving upon the point *D* and representing the varying degrees of slope of the natural surface of the ground. This straight scale which is graduated to feet right and left from its centre, has fixed to its lower edge a semi-circular protractor, by means of which it may be set to any angle of slope.

These three pieces are kept in their respective positions by means of three small flat-headed screws with thumbnuts, the middle one *D*, acting as a pivot upon which the straight scale *CC* can be turned round. In the sliding section *BB* are three slots, through which the screws pass, so that a vertical movement up or down can be given to this piece.

To use the Indicator, the sliding section is raised to the required centre height, and the straight scale turned to the angle of slope of the surface of the ground; the point of intersection of each of the side slopes with the surface of the ground is then at once seen, and their respective distances from the centre line easily read off, thus fixing without estimation or trial the exact position of the slope stakes. The length of each of the side slopes can also be at once ascertained if required. Thus in Fig. 2

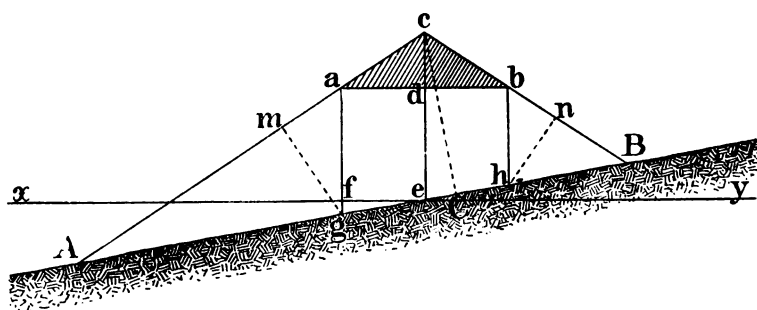


Fig. 2.

the road-bed *ab* is assumed to be 18 feet wide, and the height of the centre line above the surface of the ground, or *de* is taken as being 12 feet, while the side slopes *Aa* and *Bb* are $1\frac{1}{2}$ to 1, and the angle of the surface of the ground with the horizon is 10° . After setting the sliding

piece BB to 12 feet and turning the protractor to 10° , we at once see that Ae measures 37.2 feet and $Be = 21.6$ feet. These distances then measured out from e are the positions of the slope stakes.

When the surface of the ground presents a different slope on each side of the centre line, the straight scale must be set first to one slope and the distance read off, and then to the other slope and its corresponding distance noted.

We have said that this instrument serves also to ascertain in a very simple manner the cross-sectional area of an embankment or cutting. This may be done very quickly in the following way:—

The side slopes of the sliding section BB are prolonged upwards until they meet, as shown at c in Fig. 2, thus forming with the ground surface line a triangle ABc . A graduated square, which slides along the straight scale (kept in position by a slot, through which passes the pivot D) enables the length of the perpendicular Cc to be immediately noted. This distance, as shown in Fig. 2, is found to measure 17.8 feet. We then proceed as follows :

$$\begin{array}{rcl}
 Ae, \text{ already ascertained,} & = & 37.2 \\
 Be, \quad \quad \quad \quad \quad & = & 21.6 \\
 \text{whence } AB & - & = 58.8 \text{ feet.} \\
 \text{Half of } Cc \left(\frac{17.8}{2} \right) & - & = 8.9 \text{ " } \\
 \text{Their product} & = & 523.32 \text{ sq. ft.}
 \end{array}$$

which is consequently the area of the triangle ABc . From this we now deduct the area of the small triangle abc , which is a constant for all road-beds of the same width with the same side slopes, and is obtained by the formula $ab \times \frac{ab}{4r}$, where r is the ratio of the side slopes. In the present example this constant is $18 \times \frac{18}{4 \times 1\frac{1}{2}} = 54$ square feet, so that we have

$$\begin{array}{rcl}
 \text{Area of triangle } ABc & = & 523.32 \text{ sq. ft.} \\
 \text{Less " " " } abc & = & 54.00 \text{ " } \\
 \text{Leaves} & & 469.32 \text{ " }
 \end{array}$$

as the area of the cross section $AabB$.

We append a list of constants K for different widths of road-beds and various slope ratios to be used with the formula applying to the Indicator, namely :

$$\text{Cross sectional area } AabB = (AB \times \frac{1}{2} Cc) - K,$$

by means of which any area may be obtained in the shortest space of time possible.

This instrument will be found specially useful for the purpose of making out preliminary estimates, from the facility and accuracy with which the various dimensions and areas may be obtained.

The Slope Stake Setter and Indicator, which is copyrighted and for which a patent has been applied, may be had of Keuffel & Esser Co., New York, the sole licensees.

Table of Constants to be used in Cox's Formula: $Area = (AB \times \frac{1}{2} Cc) - K$.

SLOPE RATIO	WIDTH OF ROADWAY.									
	14 feet	16 feet	18 feet	20 feet	22 feet	24 feet	26 feet	28 feet	30 feet	33 feet
$\frac{1}{4}$ to 1	196	256	324	400	484	576	676	784	900	1088
$\frac{1}{3}$ to 1	98	128	162	200	242	288	338	392	450	544
$\frac{2}{3}$ to 1	66	86	108	134	162	192	226	262	300	363
1 to 1	49	64	81	100	121	144	169	196	225	272
$1\frac{1}{2}$ to 1	33	43	54	67	81	96	113	131	150	182
2 to 1	24 $\frac{1}{2}$	32	40 $\frac{1}{2}$	50	60 $\frac{1}{2}$	72	84 $\frac{1}{2}$	98	112 $\frac{1}{2}$	136

Other Constants may be easily obtained by the formula $ab \times \frac{ab}{4r}$ or by interpolation, which gives results near enough for practical purposes.

VERNIERS.

THE VERNIER is an ingenious contrivance, by means of which fractional portions of a graduated straight or circular scale may be accurately measured, instead of having to estimate them by means of the unaided eye. The principle, on which it is based, is the following:— Suppose that we have a scale, of which each inch is divided into 10 equal parts, and that we wish to read the same to hundredths of an inch; we place by the side of the scale another small one, called the VERNIER, *nine-tenths of an inch long*, divided likewise into 10 equal parts. It is then evident that the vernier, being one-tenth less in length than one inch of the scale, each one of the ten divisions of the same will be also one-tenth less than a division of the scale, or equal to $(1'' - \frac{1}{10}'') \div 10 = \frac{9}{100}'' \div 10 = \frac{9}{1000}$ or 0.09 of an inch; and the difference between one

division of the scale and one division of the vernier, or the "smallest reading," as it is termed, will be $\frac{1}{10}'' - \frac{9}{100}'' = \frac{10-9}{100}'' = \frac{1}{100}''$ or 0.01 of an inch. If, therefore, the division 0.1 of the vernier be placed against the division 0.1 of the scale, it is clear that the zero division of the vernier will coincide with the position of 0.1 — 0.09 or 0.01 of the scale, and if the division 0.2 of the vernier be placed against the division 0.2 of the scale, the zero of the vernier will coincide with the position of 0.02 of the scale, and so on. The converse of the above being equally true, we have therefore the following general rules for reading the graduated scale of a protractor, transit or other instrument, when a vernier is used:

- 1st.—The exact point on the scale, whose position it is required to read off, is indicated by the initial point or zero of the vernier;
- 2d.—The graduation of the scale (or limb, in the case of an instrument) next preceding the vernier, gives the number of units and primary divisions, and
- 3d.—That line of the vernier, which coincides with any line of the scale, gives the number of secondary divisions, or smallest readings, which has to be added to the reading already noted on the scale.

To ascertain the relation between the divisions of the vernier and those of the scale, let

x = value of one division of the scale,

y = value of one division of the vernier,

n = the number of divisions of the vernier, which correspond to $n - 1$ divisions of the scale,

then $x - y$ = value of the smallest reading of the vernier.

From the foregoing we obtain the following equations:

$$x - y = \frac{x}{n} \quad \text{Eq. 1.}$$

$$n = \frac{x}{x - y} \quad \text{Eq. 2.}$$

$$y = \frac{n - 1}{n} x \quad \text{Eq. 3.}$$

EXAMPLES.—The horizontal limb of a transit is graduated to 20 minutes, and it is desired to read the same to 30 seconds,

then $x = 20'$ and $x - y = 30''$

$$\text{whence } n = \frac{20'}{30''} = \frac{20' \times 60''}{30''} = 40,$$

so that 40 divisions of the vernier will have to correspond to $n - 1$ or 39 divisions of the limb.

A scale of inches is divided into tenths, and it is required to measure to 0.005 of an inch,

$$\text{then } x = .1 \text{ and } x - y = .005$$

$$\text{whence } n = \frac{.1}{.005} = 20,$$

so that 20 divisions of the vernier must correspond to 19 divisions of the scale.

If each division of a protractor is equal to 15 minutes, and 45 divisions of the vernier correspond to 44 divisions of the circle, then the smallest reading, or

$$x - y = \frac{15'}{45} = \frac{15' \times 60''}{45} = 20 \text{ seconds.}$$

The foregoing are the principles upon which the vernier is constructed, and their practical usefulness lies in the facility with which the unaided eye is able to perceive when a line is perfectly straight, or when its continuity is broken.

This device was invented, or at least first made practical use of by Pierre Vernier of Ornans, near Besançon, France, more than 250 years ago, and it is justly considered one of the most important inventions applied to measuring instruments of every kind.

Verniers are often made double, with the initial point or zero in the middle, so that a scale numbered both right and left may be read with it.

PROPORTIONAL DIVIDERS.

A CONSIDERABLE portion of the Draughtsman's work consists in making copies of drawings to a reduced or to an enlarged scale. For this purpose he has at his disposal various instruments, the principal ones being the Proportional Dividers, the Pantograph and the Eidograph.

Proportional Dividers are a very useful and ingenious instrument by means of which not only the *lines* of a drawing may be reproduced so that they shall bear in the copy a given ratio to those of the original, but the drawing may be so reproduced that the *areas* of any given plane surface, or the *contents* of any solid shall likewise be proportionate to those of the original.

Proportional Dividers are composed of two legs, 6 to 9 inches long, with fine steel points at their opposite extremities; these legs turn around a movable pivot, the position of which may be so adjusted that the ratio

of the distance between one pair of points to the distance between the other pair of points may be varied to any extent.



"Copyright, 1887, by Keuffel & Esser."

No. 435.

No. 441.

No. 439.

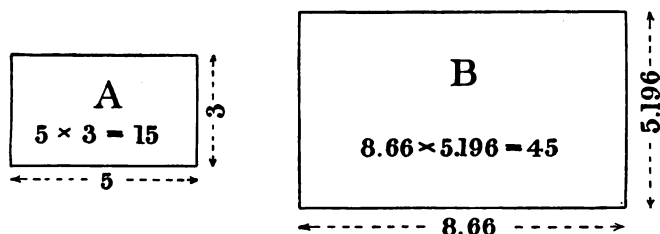
These adjustments are facilitated by means of a series of graduations or scales on the legs, any one of which may be made to coincide with a line traced across the *slider* attached to the pivot and running in a longitudinal groove in the legs. Common dividers have but one series of graduations giving ratios from 1:2 to 1:10, whilst the best instruments have four scales of graduations on the legs, namely :

- a Scale of Lines,
- “ “ “ Planes,
- “ “ “ Solids,
- and “ “ “ Circles.

THE SCALE OF LINES gives the ratio of the length of any given *line* taken in the opening at one end of the dividers to the length of the *line* as measured by the opening at the other end of the dividers, so that by it a drawing may be reproduced in any of the following proportions :

Enlarged from 1 to $1\frac{1}{11}$ or Reduced from 1 to $\frac{11}{12}$...		SCALE NO.	
1 " $1\frac{1}{11}$		1 " $\frac{9}{10}$...	$\frac{9}{10}$
1 " $1\frac{1}{7}$		1 " $\frac{7}{8}$...	$\frac{7}{8}$
1 " $1\frac{1}{5}$		1 " $\frac{5}{6}$...	$\frac{5}{6}$
1 " $1\frac{1}{3}$		1 " $\frac{3}{4}$...	$\frac{3}{4}$
1 " $1\frac{1}{2}$		1 " $\frac{2}{3}$...	$\frac{2}{3}$
1 " $1\frac{2}{3}$		1 " $\frac{3}{5}$...	$\frac{3}{5}$
1 " 2		1 " $\frac{1}{2}$...	2
1 " $2\frac{1}{2}$		1 " $\frac{2}{5}$...	2.5
1 " 3 to 10		1 " $\frac{1}{3}$ to $\frac{1}{10}$	3 to 10

The SCALE OF PLANES gives the ratio of the Squares of the openings of the opposite ends of the dividers, and is used for making the copy of a drawing in which the *area* of any given plane figure is required to bear a certain proportion to that of the original.



If, for example, we wish to make a copy of a plane figure *A*, so that its area shall be 3 times as great as that of the original, we set the slide to 3 of the scale of Planes, and take in the narrow opening the length of the sides forming the figure *A* and transfer them by the wide opening to the copy represented by figure *B*, whose *area* will then be 3 times as great as that of *A*, although the ratio of the respective *lines* of the two figures will be as $1:\sqrt{3}$ or as 1 to 1.732. It will be seen at a glance how much time is saved by this simple method of enlarging or reducing plane figures, instead of being compelled to calculate the proportionate value of each line composing the figure by multiplying it by $\sqrt{3}$.

(To be continued)



"COPYRIGHT, 1891, BY WILLIAM COX, NEW YORK."

**A Monthly Journal for Engineers, Surveyors, Architects, Draughtsmen
and Students.**

Vol. I.

OCTOBER 1, 1891.

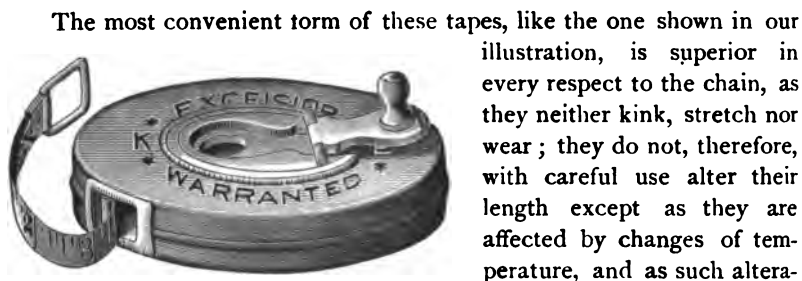
No. 3.

LINEAR MEASUREMENTS IN THE FIELD.

THE ACCURACY OF Linear Measurements, whether made in the field or in the office, is a matter of the highest importance, and is but rarely obtainable with what may be considered absolute accuracy. One source of error is to be found in the variations of temperature which more or less affect the length of all measuring instruments. Besides this one, which is an inherent quality of the best instruments, there are others, such as imperfect graduations, wear and tear, careless usage, etc., whose effects may be very greatly mitigated.

The instrument heretofore most commonly used in land surveying for measuring distances is the chain, generally made 66 feet long and composed of 100 links, each one with its 2 or 3 joining rings being 0.66 feet or 7.92 inches long. In a chain of 100 links, with two rings to each link, there will thus be 600 wearing surfaces, and if each one of these should wear but the one-hundredth part of an inch, the length of the chain is increased by six inches, which in a mile is equivalent to 40 feet. It has been found that a chain will vary about 1 inch in 1300 feet for each degree Fahrenheit, so that a chain 66 feet long, would vary $\frac{3}{10}$ ths of an inch in length for a difference of 60 degrees of temperature, or equivalent to two feet in a mile.

Chains also vary in length from the bending of the links, from the flattening of the rings, or from undue stretching, so that they require to be constantly tested with some standard base. Besides the foregoing defects, their weight and bulk, which are inconveniently great, have of late led to their being very generally replaced by steel tapes. For many years the name of *Chesterman* has been a household word to every one using steel tapes, but monopoly in this, as in so many other branches of manufacture, is now a relic of the past, and *EXCELSIOR* Steel tapes, made according to the Standard of the U. S. Coast Survey at Washington, will, we think, be found upon careful examination, second to no other makes in workmanship, material and accuracy. They are made by an improved method, which insures correct graduation and legible divisions and figures, and may be had any length up to 1000 feet, divided metrically, or in feet and tenths, or feet and twelfths.



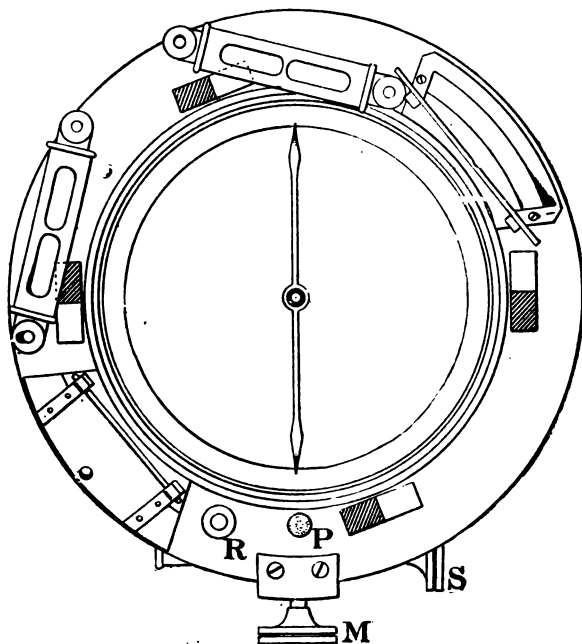
The most convenient form of these tapes, like the one shown in our illustration, is superior in every respect to the chain, as they neither kink, stretch nor wear; they do not, therefore, with careful use alter their length except as they are affected by changes of temperature, and as such alterations of length are so very small, when the variations of the thermometer from the standard temperature of the chain are but slight, measurements taken with them may be considered as correct to at least one in five thousand. For finer work, the coefficient of expansion and the modulus of elasticity must be taken into account, and special methods adopted, such as using a pair of spring balances, to ensure a perfectly even and regular tension of the tape. With the exercise of due care, and if the work be done in cloudy weather, measurements may then be made with an accuracy of 1 in 1,000,000.

It is a mooted point which method of marking Steel Tapes is the best. At present some of the markings begin clear of the end ring and its fastening, some have the initial zero at the inner end of the ring, some at the outer end, and some at the end of the tape, the end ring not being included in the measurement. As examples of these different varieties we have but to cite the well-known *Chesterman* Tapes, the *Excelsior* and the *Painé*. It seems however to us that a uniform standard is desirable, and with a view to effecting this object, we should be pleased to receive the opinions of our readers and to publish a resumé of them for the information of the profession.

*ENGINEERING AND SURVEYING INSTRUMENTS.**(Continued).*

THE PLAIN TRANSIT.

THE VERNIERS, by means of which horizontal angles are measured, are double, and are attached to the top plate; in Keuffel & Esser Co's Transits (which we have under consideration) they are placed at either 90 or 45 degrees with the telescope as may be desired; in the latter case the operator is able to note their readings without altering his position after sighting. The two verniers are placed exactly opposite each other, so that the reading of the angle measured may be made by the one and checked by the other, and also to ascertain whether the graduations of



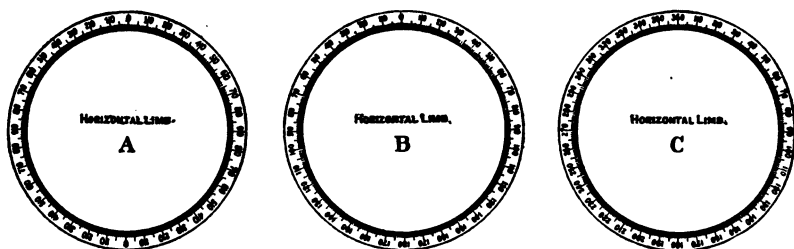
the horizontal limb are exactly spaced and perfectly centred. The two are also used when repeating the measurement of an angle, so that by taking the mean of several readings a greater degree of accuracy may be obtained; in the present day however, when such precision is arrived at in the graduating and centring of circles and verniers, the repeating of angles is less resorted to than formerly; still no transit, however accurately it may be graduated, will be without the second one, as it is essential for testing the accuracy of the graduations. The verniers, which read

both right and left, are marked by the distinguishing letters *A* and *B*, and are covered by hinged shades lined with white, which protect the glasses and at the same time serve as reflectors to facilitate the reading of the divisions. In actual practice it is usual, after verifying the adjustments of the instrument, to keep one vernier covered, and to take all readings from the other one, thereby avoiding any inaccuracies which might be caused by a possible slight disagreement between the two verniers.

The verniers are placed inside of the graduated circle as it is considered that this position affords to them more protection and that they are not so liable to get out of adjustment. It is also preferable as it gives more strength and more room for the standards. We are aware that some makers place the vernier outside the graduated circle; the result is the same and seems to us to be a matter of taste combined with special peculiarities of construction. If our readers, however, have any special preferences for one position or for the other, or consider that the one possesses advantages not belonging to the other, we should be very pleased to hear from them and to publish their remarks in our next issue, so that the profession in general may have the benefit of their practical experience.

The upper plate carries a finely graduated level, while another one is attached to one of the standards at right angles to the former one; these permit of the plate being accurately leveled in all directions by means of the screws *L* as already described. When, however, the verniers are placed at 45 degrees, both levels are placed on the upper plate, and the telescope standards are made of an entirely original patented pattern, which, while allowing their two feet to be still kept sufficiently apart, does not destroy their symmetry.

There are two points in the graduations of the horizontal limb of a



Transit which require particular attention; they must be equally spaced or distanced one from the other, and the centre of the radial lines forming the graduations must be identical with that of the instrument itself. A very slight error in either of these points would produce very serious results, seeing that a discrepancy of 1 minute in the reading of an angle by the Transit is equivalent to a difference of 18.37 inches at a distance of a

mile. The graduations of the horizontal limb are numbered in various ways as shown by Figs. *A*, *B* and *C*. They are also sometimes numbered in double rows from 0° to 360° , one reading to the right and the other to the left:—also with one continuous row from 0° to 360° as *C*, and another one in quadrants (0° to 90° each way) as *A*. These are in a great measure matters of personal choice dictated by the necessities of the work to be undertaken.

(*To be continued.*)

SERIES OF NUMBERS WITH EXAMPLES OF THEIR PRACTICAL APPLICATION TO SCIENTIFIC PURPOSES.

(*Continued.*)

WE MIGHT ARRANGE the logarithms given in our last issue in the form already adopted for series of numbers, thus:

<i>A. P.</i>	0	.301	.477	.602	.699	.778	.845	.903	.954	1.000
<i>G. P.</i>	1	2	3	4	5	6	7	8	9	10

although it must be noted, that when so placed, they do not form *complete* series of numbers in regular progression, as neither the arithmetical nor the geometrical rates of progression are observed—many of the numbers being intermediate ones intended merely to give the logarithms of the first ten numbers. If taken conjointly, however, it will be found that *all* the properties of series of numbers given in our first article belong to them, and that the operations of multiplication, division, etc., as described, may be readily performed by their means.

The first and simplest application of the principles set forth which we shall now notice is that which is to be found in

THE SLIDE RULE.

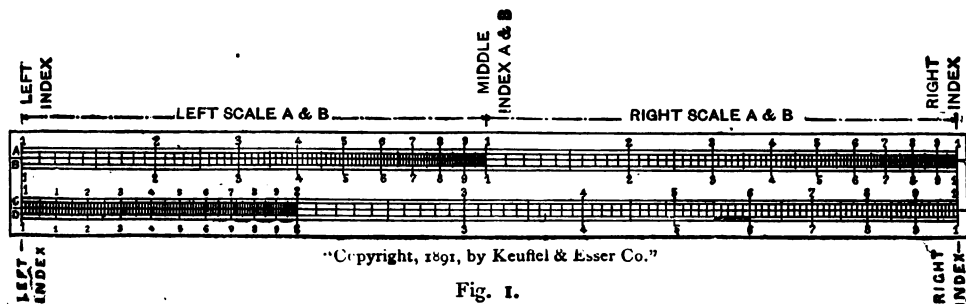


Fig. 1.

If we take two strips of paper 10 inches long, each divided upon one edge into 1000 equal parts, and if against the starting point or zero of each we place the figure 1, then at the end of 301 parts we place the figure 2,

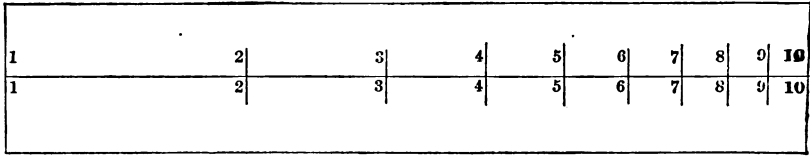


Fig 2.

at the end of 447 parts the figure 3, and so on, we shall have, as shown in Fig. 2, what is termed a logarithmic scale, the figures of which represent a series of numbers in Geometrical Progression, and the corresponding unequal spaces a series of numbers in Arithmetical Progression. It must however be borne in mind that these figures as they stand on the scale are not a perfect series of numbers in *G. P.*, neither do the unequal spaces represent a perfect series of numbers in *A. P.*; if we however eliminate the figures 3, 5, 6, 7, etc., we shall find that the remaining ones 1, 2, 4 and 8 are in perfect geometrical progression, and that the spaces between 1 and 2, 2 and 4, and 4 and 8 are all equal, so that they are now in arithmetical progression. The equal spaces are subdivided, and the figures added to make a complete *scale*, but they do not in any way nullify the principles laid down.

The practical application of the foregoing is effected by means of the following further general principle, viz :

A *unit* may be represented by a SPACE of any length measured from a given point : and a *number* composed of two or more units may be represented by a DISTANCE composed of a similar number of equal spaces. These distances may be increased by adding or joining on to them other spaces or distances, or decreased by taking from them some of the spaces or distances of which they are already composed.

If we now take one of the graduated strips of paper, and lay it lengthways by the side of the other one in such manner that the figure 2 of the lower strip coincides with the figure 1 of the upper one (as shown in Fig. 3),

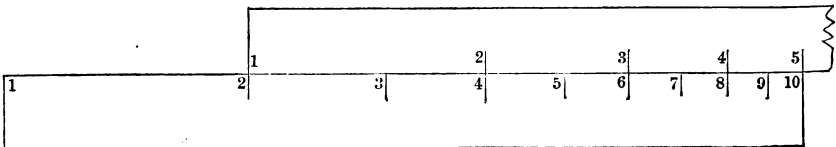


Fig. 3.

we, as it were, add on one space to each of the spaces of the upper scale, so that the coinciding positions on the lower scale give us the values of the upper scale spaces *plus* this added space. This is equivalent to the adding together of two numbers of an arithmetical series. But the *number* which we find on the lower scale is the product and not the sum of the two numbers whose spaces have been so added. Thus with the initial 1 of the upper scale placed against 2 of the lower scale, we find under 4 of the upper scale the figure 8 on the lower scale, which is the product of 2 and 4, and not their sum.

It will be also seen that the ratio of all coinciding numbers on the two scales is the same as 1 to 2, or as the ratio of the initial 1 of the upper scale to the number of the lower scale against which it is set. Similarly, if the initial 1 of the upper scale be placed against 3 of the lower scale, all numbers of the upper scale will be in the ratio of 1 to 3 to their coinciding numbers of the lower scale: whence, *place the slide of a Slide Rule as we will, all the coinciding numbers of the slide and the rule form equal ratios, whilst any two such ratios taken together form a perfect proportion.* The importance of this principle of ratios cannot be over-estimated when it is noted that it is the basis of the common arithmetical rules of multiplication and division, as also of that branch of Mathematics which treats of the relations of the sides and angles of triangles, or Trigonometry. Many of Euclid's propositions also show us that geometry abounds in ratios. Multiplication is but another form of the proportion $1 : a :: b : x$, and division is likewise reducible to the proportion $a : b :: 1 : x$. The sine, cosine, tangent, etc., of a triangle are also but the expressions of the ratio existing between two of the three sides of a right-angled triangle, this ratio always varying with the angle.

We can also with these two slips of paper perform calculations in Evolution and Involution; in fact, all the operations referred to in our first article may be effected by their means.

If now the spaces be decimally divided and subdivided, and if we attach to the initial 1 the value of any decimal part or decimal multiple of 1, we obtain a scale with which operations extending to many figures may be quickly and accurately performed.

Such are, briefly stated, the principles upon which the construction of the Slide Rule are based, one slip of paper representing the Rule, and the other the Slide. For further details we must refer the reader to our treatise on "The Slide Rule," in which the various rules for applying it to the solution of mathematical problems are fully given, as also demonstrations for working out a number of engineering and other formulæ.

(To be continued).

THE COMPASS.

A Monthly Journal published the first of every month, at 127 Fulton Street, New York City.

WILLIAM COX, - - - - - Editor.
KEUFFEL & ESSER CO., - - - - - Publishers.

SUBSCRIPTION \$2.00 per year, in advance, postage paid. Single Copies, 20 Cents each.
CORRESPONDENCE should be addressed to the Editor of *THE COMPASS*, 127 Fulton Street, New York City.

All such bearing upon the topics to which the Journal is devoted, will be thankfully received and acknowledged with pleasure.

CONTENTS.

	PAGE.
Linear Measurements in the Field, - - - - -	33
Engineering and Surveying Instruments, - - - - -	35
Series of Numbers with Examples of their Practical Application to Scientific Purposes	37
Some Remarks concerning Instrument Adjustment, - - - - -	41
Speedy Calculators, - - - - -	44
Proportional Dividers, - - - - -	46
New Books, - - - - -	48

TO OUR READERS.

WE HAVE GREAT pleasure in drawing the attention of our readers to some-very interesting remarks in this issue on the subject of Instrument Adjustments, for which we are indebted to Messrs. Buff & Berger, the well-known instrument makers of Boston. Their careful perusal will amply repay the time thus spent.

We have also received from an able European contributor an interesting article on the subject of Paper for Blue Process Printing, but regret that it came to hand too late for insertion in the present issue. We advise our readers who have frequent recourse to this process to consider the recommendations contained in this article (which will appear next month) as the obtaining of clear, distinct, strong and lasting prints depends very largely upon their adoption.

A LEADING JOURNAL in referring to *THE COMPASS* writes : "In the first issue which is now before us, the name of Keuffel & Esser Co. and mention of their instruments occur with perhaps too great frequency." As the name of the above firm is very widely known as being synonymous with excellence and merit, such mention is in a great measure unavoid-

able; and as their aim and wish is always to offer none but first-class articles which will give entire satisfaction, the bringing of their name before the public, if kept within due limits, cannot be looked upon as altogether objectionable. We feel it also due to ourselves to state that until our journal is well before the public, such a course is also more necessary than we should otherwise desire, but we hope to be in a position to give to our readers in later issues some information concerning what other instrument makers are doing, and shall not hesitate, when anything new and good is presented to us, be its source what it may, to give it its deserved publicity.

SOME REMARKS CONCERNING INSTRUMENT ADJUSTMENTS.

"Copyright, 1891, by Buff & Berger, Boston, Mass."

CONTRIBUTED BY BUFF & BERGER, BOSTON, MASS.

THE ADJUSTMENTS and the mechanical and optical perfection arrived at by the maker of instruments used in Geodesy, although satisfactory when they leave his hand, are liable to become disturbed by use, and should be relied on only to a certain extent. It is therefore of vital importance that the person using an instrument should be perfectly familiar with its manipulations and adjustments. He should be able to test and correct the adjustments himself at any time, in order to save time and expense, as well as to possess a thorough knowledge of the condition of the instrument. It is evident that if the character of an instrument is not properly understood, or if the adjustments are considerably out, the benefit due to superior design and workmanship may be entirely lost, and under these circumstances such an instrument may be little better than one of lower grade.

In the best types of modern instruments the principal parts are so arranged that they can be adjusted by the *method of reversion*. This method exhibits an existing error to double its actual amount, and renders its correction easy by taking one-half the apparent error. Thus—errors of eccentricity and inaccuracy in the graduations are readily eliminated by reading opposite verniers and *reversing* the vernier plate 180° on the vertical center and taking the mean of the readings, and by repeating the measurement of an angle by changing the position of the limb so that the measurement will come on different parts of the graduation;—striding levels and levels mounted on a metal base are readily tested by reversing their position end for end, and in the transit plate levels the adjustment is assured by turning the vernier plate 180° ;—and errors of the

line of collimation are detected or eliminated by reversing the telescope over the bearings, or through the standards, as the case may be. In short, an instrument whose important parts are not capable of reversion in one way or another, cannot be examined quickly and accurately.

The adjustments of an instrument, and particularly those of its cross-wires, should be taken up successively, in a systematic manner. The proper way is to select a place from which they can be conducted in succession without moving the instrument, as none of the adjustments should be completed independently of the others. This method is followed by the maker, and will save time and vexation. Any auxiliary apparatus that may be available, such as collimators, etc., will be of great service and expedite the work. One of the most important considerations in making adjustments (when the same are greatly disturbed, as when new wires have to be inserted), is to place all the respective members in an approximate adjustment without introducing any strains except those properly belonging to the action of the adjusting screws themselves. The more natural the method, and the less internal strain is introduced in bringing these adjustable parts into position, the more lasting will be the final adjustments, provided the instrument is otherwise in a good condition.

It is important that all adjusting screws and nuts should fit truly on the surfaces against which they operate, and with only a bare film of some tallow between them, so as to assure a true metallic contact, and that they be brought to a firm bearing, but without excessive strain. Opposing screws and nuts should always work somewhat freely, so that the finger will feel when the parts come to a true bearing. A moderate pressure applied with an adjusting pin about one and one half inches long, and held between the thumb and forefinger, will then make a perfect contact. For instance, after the opposing capstan-headed screws of the cross-wire reticule have come to a bearing, it is only necessary to give them each a slight turn, say from 20° to 30° (with the usual pitch of these screws) in order to insure such a tightness that a moderate pressure of the finger upon these screws, or an accidental gliding of the hand over them, cannot change their relative position. On the other hand, if one pair of these opposing screws be fastened tightly during the tentative process of adjustment, there will be, in all likelihood, at the end, an excessive strain exerted upon the pair of opposing screws at right angles, which will make itself felt at any change of temperature, or whenever any external pressure may be momentarily applied to them. It is but natural that these continual changes in the resultant pressure must affect the adjustments in a like manner. To obviate such changes the procedure should be as follows:—

Having placed the principal wire of an instrument (the vertical wire

in a transit and the horizontal wire in a level) approximately in a plane perpendicular to the horizontal axis of revolutions of a transit, or to the vertical axis of revolution of a leveling instrument, the horizontal and vertical wires are to be adjusted approximately for collimation with the capstan-headed screws *only moderately tightened*. This accomplished, the capstan-headed screws of each pair in succession are then to be unscrewed about one-quarter turn, and again screwed tight the same amount. Now if the two pairs of opposing screws have exerted no undue strain upon themselves, the telescope tube and reticule, the principle wire will still be in the perpendicular plane; but if the screws have been used too much the wire will have slightly moved out of the perpendicular plane. Therefore all four capstan-headed screws will have to be released again, say about $\frac{1}{8}$ turn, so that they may be moved simultaneously until the principal wire is again in a plane perpendicular to the axis of revolution, and then each pair in succession must be again tightened an equal amount. The adjustment of the wires for collimation must now be made in turn—the less important wire should always be taken up first—by slightly releasing the capstan-headed screw *away** from which the wire must be moved, and tightening the opposite screws the same amount, and repeating this process until the adjustment is gradually perfected. If during this operation either or both of these wires had become displaced so much that the capstan-headed screws had to be moved more than a quarter turn, it would be advisable to slightly release all four of them again, in succession, and commence anew.

It should be here said, too, that the forces applied by the capstan-headed screws cannot break or effect the tightness of the wires in any sense, since the reticule, as made by us, although very light of weight, is of a very stiff form. Too great a pressure exerted by the capstan-headed screws, against the outer tube of the telescope, may, however, change the form of the main tube, thereby affecting the true fitting of the object-slide, and creating friction of so serious a nature as to lead to the fretting of the object-slide mentioned in other paragraphs.

In following the above-described course, the cross-wire reticule occupies a position in the telescope free from any excessive side strain, the result of which is found in the greater permanency of these adjustments, and

* We speak here exclusively with reference to the more customary instruments of American manufacture, where the shoulders of the capstan-headed screws bear against the outer tube of the telescope, and where the adjusting threads are contained in the wire reticule. In other designs where, as in most instruments of Continental Europe, the capstan-headed screws are made to butt against the wire reticule, the capstan-headed screws *towards* which the wire must be moved, must first be loosened. In the latter case this action is identical with that of opposing nuts used for the adjustment of most spirit levels on American instruments.

although it may require a little more time for an inexperienced person to make the adjustments in this manner, the satisfaction derived from their greater permanency will more than recompense for the extra time spent on them. The writer believes, moreover, that the adjustments should be made at leisure, and that they should not be meddled with, unless they appear to be permanently deranged, when, ordinarily, the adjustments will merely require a very slight turn of the capstan-headed screws and opposing nuts *in the proper direction*. Unequal exposure of the instrument to the sun, or exposure to sudden changes of temperature, may for a time expand some of its parts more than others, so that the instrument may seem to be slightly out of adjustment. In such a case it would be better to stop temporarily and cover the instrument with a bag to allow the temperature to become equalized, instead of attempting adjustments that would need to be repeated when the instrument is again in a normal condition. The use of metal of different co-efficients of expansion in the construction of corresponding parts of an instrument will naturally lead to a permanent derangement of an adjustment while the temperature of an instrument is greatly altered after the adjustments have been completed. A similar result is caused if the bubble of a spirit level should not lengthen symmetrically from the center of its graduated scale in varying temperatures. These imperfections, however, seldom occur in instruments of modern make; or if they occur, they are generally caused because the principal constituents, glass and metal, are substances of widely differing co-efficients of expansion; but these imperfections are generally so slight in instruments well made, as to be of little practical value, and may be overcome by adjusting the instrument while at a mean temperature of an entire season.

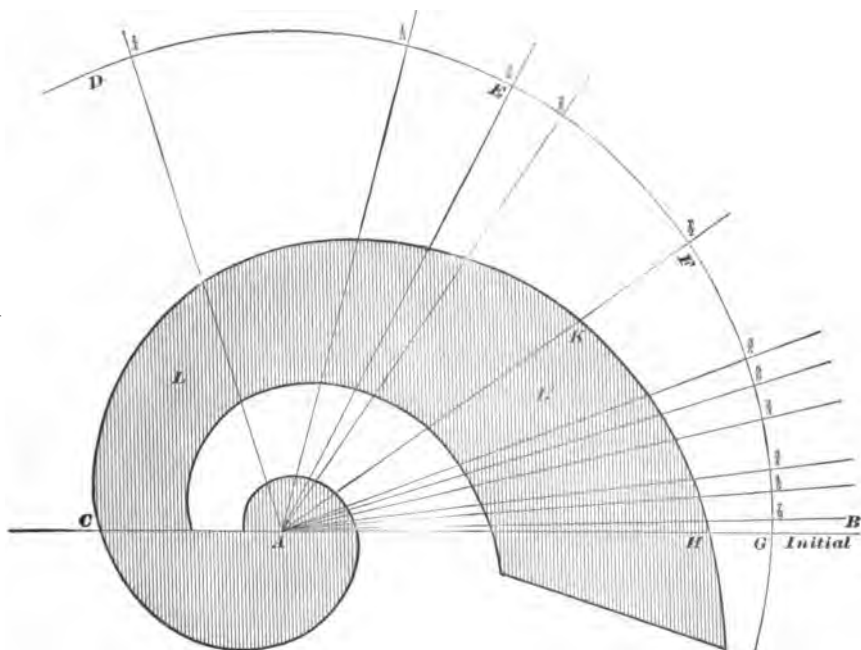
If an instrument does not remain in adjustment a reasonably length of time, the cause that leads to the trouble, such as a loose object-glass or cell, loose object-slide, worn out screws or bearings, etc., must be discovered and remedied, and if this is beyond the scope of the operator the correction should be made by an instrument maker.



SPEEDY CALCULATORS.

IN OUR LAST issue we stated that the average Pressure of Steam in an Engine Cylinder could be very easily obtained by means of a Logarithmic Spiral Curve. We shall not attempt in the present article to give a full description of the remarkable properties of this curve, as that will be done in a subsequent article on "Series of Numbers," but purpose to show briefly the graphical method whereby practical use may be made of it to solve the problem above stated.

On a sheet of stout drawing paper an arc $DEFG$ is traced as shown in the figure, with a radius of about 6 inches, whilst from the centre



A , radii are drawn to the circumference at varying and suitable angles to the horizontal line CG . These radii are marked with the different ratios of the cut-off of the steam, as $\frac{1}{8}$ ths, $\frac{1}{4}$ ths, $\frac{1}{3}$ rds, etc. To complete the instrument, fix this sheet of paper on a drawing board, and take a logarithmic curve (black rubber ones are the best, as they vary the least with the temperature or the amount of humidity in the atmosphere) and pass a fine needle through its centre and also through the centre A of the arc $DEFG$, so that the curve may revolve freely around its axis on the sheet of paper. Then apply a convenient scale of equal parts, such as 30 or 40 to the inch, so that it will lie close along the base line AG , and have its zero at the centre A . Turn the curve now round until the distance AH is equal to the initial pressure of the steam in the cylinder, then hold the curve steadily in this position and lay the scale of equal parts along the radius of the cut-off for which the average pressure is sought, keeping as before the zero at A . The distance along this radius from the centre A to the edge of the curve is then the mean pressure for the given cut-off.

This curve may also be used for a variety of other calculations, such

as the reduction of yards into metres, pounds pressure per square inch into inches of mercury, etc. The centre of curvature of a given curve, or the centre of a circle may also be easily ascertained with it. When using this curve, care must of course be taken to know that it is a perfectly accurate one, and that the ratio of curvature is suitable for the divisions of the arc adopted. The publishers of THE COMPASS can supply both correct curves and arcs graduated as shown for the purpose of obtaining the Mean Effective Pressure of Steam with any cut-off.

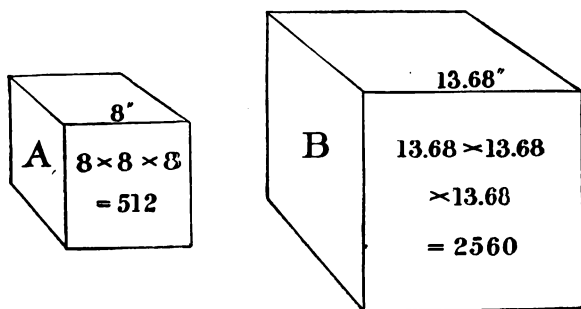
(To be continued).

PROPORTIONAL DIVIDERS.

(Continued).

The SCALE OF SOLIDS gives the ratio of the cubes of the openings of the opposite ends of the dividers, and is used to reproduce any solid figure, whose *contents* are required to bear in the copy a given proportion to those of the original.

Suppose, for instance, we wish to make a copy of the cube *A*, whose



side is equal to 8 inches on a scale of 1 inch = 1 foot, but the contents to be 5 times as great as those of *A*. We set the slider to 5 of the scale of Solids, and take in the narrow opening the length of the different sides and transfer them by the wider opening to our copy, which will have the dimensions of *B*, its cubic contents being 5 times as great, and its sides $\sqrt[3]{5}$ or 1.71 times as long as those of *A*. On measuring our copy *B*, it will be found that the length of a side is by the same scale of 1 inch = 1 foot equal to 13.68 inches; and that the result as obtained by the instrument is correct, is proved by cubing the sides 8 and 13.68, which gives us respectively 512 and 2560, the latter being 5 times the former.

The time saved by using this instrument is even more apparent in the case of solids than in that of planes.

The SCALES OF CIRCLES gives the ratio of the diameter of a circle (in some cases the radius) to the side of any inscribed regular polygon from 6 to 20 sides, and is used for dividing the circumference of a circle into any number of equal parts up to 20.

A line marked *G. S.*, found on some instruments on this scale, gives that proportional division of a straight line into two parts wherein the whole line is to the greater part, as the greater part is to the lesser part, whence the greater part is equal to the whole line multiplied by $\frac{(\sqrt{5} - 1)}{2}$

or 0.618. The greater part is thus a mean proportional between the lesser part and the whole line.

The illustrations in our last number show different models of proportional dividers of the very best quality and workmanship, namely :

No. 435— $7\frac{1}{2}$ inches long, finely divided for lines and circles.

No. 437—like No. 435, but $8\frac{1}{2}$ inches long, divided for lines and circles, and with rack movement, as No. 439, enabling an easy and close adjustment of the slider to be made to the lines of the scales.

No. 439—9 inches long, divided for lines and circles, with rack movement and movable steel points, which are held firmly by screws, so that they can be reset to their original length in case of breakage.

No. 441—9 inches long, finely divided for lines, planes, solids and circles, with micrometer adjustment, permitting of accurate settings both of the openings of the points and also of the slider to any particular graduation.

Similar models of inferior quality and finish may also be had, but in the case of instruments, of whatever kind, the best alone should be used, if accurate work is either desired or expected to be done. Those described are strongly recommended, and may be used without the slightest hesitation.

We have often thought that if the ordinary Proportional Dividers had the scale of circles, which is but little used, replaced by a graduated scale of say 250 equal parts, from point to point, any ratio might be set off between the openings of the two ends. The Dividers could then be used for many other purposes than those indicated by the different scales graduated on the instrument itself.

NEW BOOKS.

THE SEXTANT and other Reflecting Mathematical Instruments, by F. R. Brainard, U. S. N., is the latest addition to Van Nostrand's well-known Science Series. This treatise gives in concise form the history of the Sextant, with a clear exposition of the principles upon which it is constructed, and the method of using it, the whole being illustrated by numerous and distinct line sketches. The various adjustments of the instrument, together with the errors to which it is liable with the necessary corrections for same are also fully treated. Descriptions of the Box Sextant, the Reflecting Circle, Dip Sector and the Artificial Horizon are also given, with some practical hints, suggestions and wrinkles which will be found very useful.

A MANUAL OF LAND SURVEYING, by F. Hodgman, M. S., C. E., and C. F. R. Bellows, M. A., C. E. We have before us the fifth edition of this well-known work, which has been carefully revised, rearranged, and largely rewritten by Mr. F. Hodgman. This treatise gives in a clear and concise manner the mathematical and practical principles of land surveying, with general descriptions of the instruments used, and methods of procedure. To many, however, the most valuable portion of the book will be that contained in Chapters VI to XII, which deal with the legal aspect of the surveyor's duties. In these will be found clearly set forth the system of the United States Surveys, which is the method most generally adopted in this country, together with the authorized methods of subdividing sections under the various conditions which present themselves. They also state very fully the principles which govern resurveys, which are almost wholly principles of law and control the mathematical principles which govern in the case of original surveys. These principles are all given fully and clearly, and are supported by the weightiest authorities and by the decisions of the highest courts in the land.

WE HAVE IT on the authority of the Canadian *Patent Review* that the Patent Office at Washington, has a printed circular which it sends to inventors of machines for perpetual motion, in which the impossibility of the thing is set out. Judging from the number of enquiries made in other quarters, a similar circular to be forwarded to those seeking information respecting an instrument for detecting the presence of gold and silver, or by means of which veins of these precious metals may be traced, would not be altogether useless.



"COPYRIGHT, 1891, BY WILLIAM COX, NEW YORK."

**A Monthly Journal for Engineers, Surveyors, Architects, Draughtsmen
and Students.**

Vol. I.

NOVEMBER 1, 1891.

No. 4.

ENGINEERING AND SURVEYING INSTRUMENTS.

(Continued).

THE PLAIN TRANSIT.

IN THE LATEST and most improved forms of transit the compass box is sunk below the upper surface of the top plate, and the rim is beveled toward the centre as shown in Fig. 1, page 19, the graduations being on this beveled edge. These graduations are usually figured from zero to 90 on each side of the North point, then in reversed order to zero at the South point. The North and South points are exactly in line with the telescope, that is, they coincide with the line of collimation, and the East and West points are marked on opposite sides to those on which they really lie, so that the needle may indicate the true direction to which the telescope is turned.

The needle is bent upwards at each extremity, as this allows of its point reading directly into the lines when the needle is not perfectly balanced. The needle is made heavier near the points than in the centre, and is consequently more sensitive than any edge-bar or flat-needle can be, as this shape holds the magnetism better; it has also an agate centre, and the milled head *P*, page 35, for raising and lowering it, is both small

and so placed that it is as much out of the way as possible. The socket which holds the pivot upon which the needle swings, can be unscrewed in case of accident and the pivot can be replaced by any good sewing needle which fits the hole. A small piece of fine wire is coiled round the south end of the needle, so that its inclination or dip may be compensated.

The needle indicates of course the magnetic North, but a considerably improved appliance for setting off the variation of the needle is often attached to these transits. The compass ring is then made movable, and it is capable of being partially revolved on the bottom plate of the compass box, being operated by means of a rack and pinion *V* (Fig. 1, page 19.) placed below the upper surface of the top plate *H*. The shaft of this pinion extends above the top plate and its small head *P* is provided with holes to receive the adjusting pin or lever, by which it may be turned as required. This is a much more delicate means of adjustment than the milled thumbnut, whilst the rack and pinion, being placed under the plate instead of above it, are protected from rain and dirt. The accurate setting off of the variation of the needle is determined by a small graduated arc on the bottom plate of the compass box in conjunction with a vernier on the vertical portion of the compass ring.

These transits, although so much stronger in all their parts, and more rigid than the older styles, will yet be found to weigh from 20 to 25 per cent less, owing to the substitution of ribs and braces for heavy castings, as also to their improved construction. This substitution is particularly noticeable in the upper and lower plates, *H* and *I*, Fig. 1, page 19.

Having examined the Centres, with the Top Plate, the graduated Horizontal Limb, the Leveling plates, and their various attachements, we now come to the second group of parts, namely, the Standards with the Telescope and its attachements.

It is essential that the telescope of a transit shall at all times be perfectly steady and free from vibration. To insure this, the standards, as shown in the figure, have their legs well spread out and their feet placed close to the compass box, where the top plate is strongest and offers the most substantial support. The form of these standards is peculiar; after being cast the legs are twisted by special means so that their apices may converge inwardly in the form of a cone. This mode of manufacture changes the arrangement of the particles and imparts firmness and rigidity to the standards; it also allows of a much shorter telescope axis being used, which is of itself a very great advantage. When the verniers are placed at an angle of 45° with the telescope, the standards are made of an entirely original and patented design, one branch or leg being nearly vertical whilst the other one is inclined beyond the ordinary extent and is twisted as shown in the figure, page 3, No. 1. The same rigidity is thus



Patented Dec. 3, 1889, and Oct. 13th 1891.
Other Patents pending.

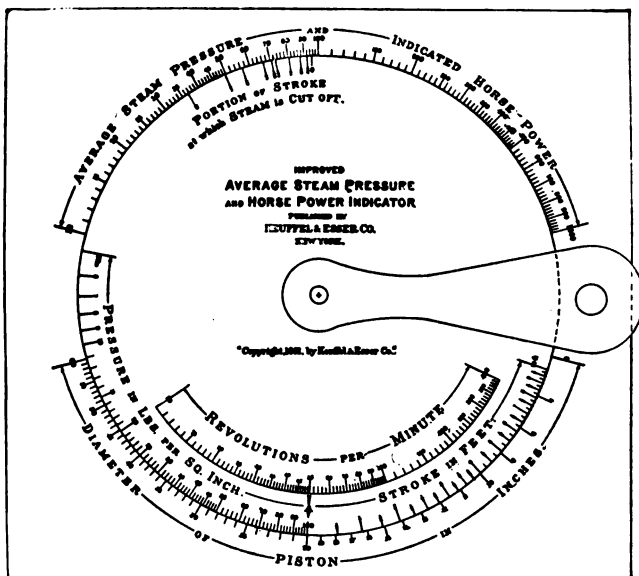
obtained as when the standards are of the usual form applicable to verniers at 90° with the telescope, and the symmetry of the standards is maintained.

The construction of the telescope of a transit requires the greatest care and accuracy, and to do good work it is necessary that every means be provided for the perfect adjustment of its various parts. When we look through a telescope simply for the purpose of viewing an object more distinctly, it is not of much consequence whether our sight is directed toward that object in an absolutely straight line or not; but when a telescope is used for the purpose of measuring angles or distances, it is evident that the line of sight passing through the optical axis of the instrument should be perfectly straight, and that we should be able to fix it directly upon the centre of the object whose position or distance we wish to define. This

optical axis is determined by the intersection of two fine wires or spider's webs placed at right angles to each other inside the telescope, and the line passing through it from the eye piece to the object glass is called the *line of collimation*. In order to understand the adjustment of this line of collimation, it is necessary to be acquainted with the construction of the telescope. For this purpose we shall in our next number briefly describe the *object-glass* or *objective* with its mountings, the *eye piece* with its mountings, and the *diaphragm* in the *focal plane* of the object glass, to which are attached the *cross-wires*.

(To be continued).

SPEEDY CALCULATORS.



THE ACCOMPANYING illustration shows another means whereby the Average Pressure of Steam in an Engine Cylinder may be instantly found. Like the Pump Indicator (page 12), the AVERAGE STEAM PRESSURE AND HORSE POWER INDICATOR also consists of a square foundation plate with a circular disk about 8 inches diameter, both being suitably graduated in accordance with the factors of the formulæ whose solution they give.

In order to obtain the Average Pressure of steam with any ratio of cut-off, the zero of the Cut-off Scale on the disk is set to the initial pressure on the plate, then opposite any given cut-off will be found the average pressure in pounds per square inch for the whole stroke.

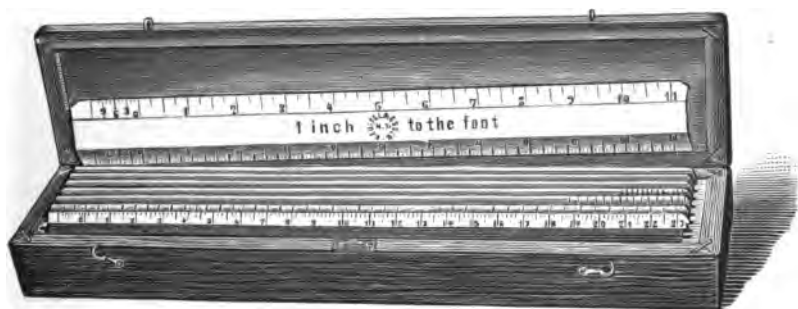
This Indicator serves however a further and more important purpose. With it the horse-power of a Steam Engine is found almost instantaneously, and that, whatever may be the ratio of cut-off. By means of the radial edges of the movable arm shown on the right, the various factors of the formula

$$\frac{D^2 \times .7854 \times 2S \times R \times P}{33000} = \frac{D^2 \times S \times R \times P}{21008}$$

$= D^2 \times S \times R \times P \times .0000476$ are alternately brought into contact with each other, (as explained in the directions printed on each Indicator) and the resulting horse-power is then found opposite the zero of the cut-off scale; the horse-power with the given cut-off being found, as already explained in the case of the average pressure of steam, on the top outer scale opposite the ratio of cut-off. Thus by a very simple manipulation, the horse-power of any Steam Engine may be almost instantly obtained, and that with a degree of precision beyond all practical requirements.

Another Indicator, similarly constructed, gives the horse-power of a Fall of Water or of a Turbine, when the height of the Fall and the Volume or Discharge of water are known; or with the scales slightly modified, it gives the horse-power of a Turbine or Water Wheel when the head of water, number of square inches of water vented, or diameter of nozzle are known, as well as the percentage of efficiency at which the Turbine or Water Wheel is rated; it also shows at a glance the combinations of head and volume of water etc. required to produce a given horse-power at a given rate of efficiency.

LINEAR MEASUREMENTS IN THE OFFICE.



THE ACCURACY of linear measurements in the office is of as great importance as those taken in the field, and a map or chart upon which the measurements taken with the tape or other instrument are not correctly reproduced, may be the cause of serious and even deplorable re-

sults. It is necessary therefore that the instruments used for plotting from the field notes should be both accurately divided and made of such material as is the least likely to be affected by changes of temperature or damp. Ivory has always been in favor for scales, as the graduations can be made on its surface both fine and distinct; it is however liable to shrink considerably. Boxwood has also been much employed, but owing to the naturally greater indistinctness of fine divisions, only became popular by reason of its more moderate price. The material is however very suitable, being less subject to variations than ivory, and if close divisions could be made clear and distinct, so as not to tire the eye, it would probably be the best material for scales known.

The increasing use of celluloid to replace ivory in the manufacture of so many artistic objects and nick-nacks of various kinds has led to its being also adopted in several ways in the construction of drawing and other instruments. The most happy of these is undoubtedly its application to draughting scales. Those so well known by the name PARAGON are made of the best seasoned Boxwood, the bevels being coated with celluloid, applied by a special process which insures its being very thin and evenly spread, so that it is governed and controlled by the good qualities of the boxwood; it thus becomes perfectly homogeneous with the wood, of which it may be said to virtually form a part, and consequently will not shrink. It will always remain white, and the divisions can be made very close and will still be distinct and legible, even more so than on ivory. PARAGON scales are machine divided and guaranteed correct to the U. S. Standard.

Scales are generally made in one of two ways, flat or triangular. The flat ones have manifest advantages and are rapidly superseding all other forms. A flat scale will last much longer than a triangular one, as the divided surfaces of the latter soon become blurred by their friction on the drawing; the divisions of the former are also much more easily distinguished, as they are nearly in the same plane as the drawing. In the case of triangular PARAGON scales however, these objections are to a great extent overcome, as their improved shape, as shown in Fig. 1, prevents



Fig 1.

the wearing away of the divisions and insures closer contact with the drawing and a better angle of vision.

The *scale* of a drawing is the ratio of its linear unit to the linear unit

of the field measurements, as 1 inch = 1 foot, 10 chains to an inch, etc. It is therefore necessary to adapt the drawing scale to the unit of measurement employed in the original work, so that it may be transferred to the map or plan easily and in a clear and recognizable manner. Scales are usually divided and figured in three distinct ways:—

- 1st.—inches, fractional parts or multiples of an inch to the foot.
- 2nd.—inches divided decimally, and
- 3rd.—the foot divided decimally.

In the first class, the inch, fractional part or multiple of the inch, is, as shown in Fig. 2, divided to represent a foot, that is, duo-decimally.

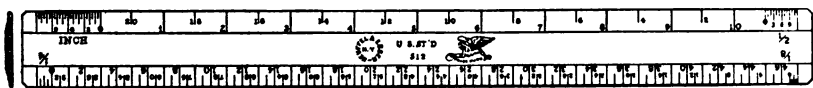


Fig. 2.

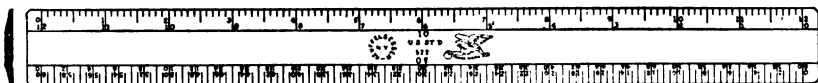


Fig. 3.

The principal scales belonging to this class are those of $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$, 1, $1\frac{1}{2}$ and 3 inches to the foot; they are generally used by Architects and Mechanical Engineers.

In the second class, shown in Fig. 3, the inch is divided decimally into 10, 20, 30, 40, 50, 60, 80 or 100 equal parts, while in the third class the foot is divided decimally into 100, 200, 300, 400, 500, 600, 800 or 1000 equal parts. These two classes are used by Civil Engineers and Surveyors, and are generally called *Chain Scales*.

A scale may be further "open divided" or "full divided". The former are represented by Fig. 2, in which the units only are marked along the whole length of the edge, and the first foot is subdivided into inches and fractions of an inch. Fig. 3 is a full divided scale, or "Chain Scale", and the equal decimal divisions are carried along the whole length of the edge. These latter, although generally divided to decimals of inches, are sometimes divided as inches to the foot.

Sets of divided scales, which are as valuable and as delicate as compasses or dividers, should be well taken care of. The most efficient way to do this is to keep them in a box as shown in our first illustration. These are strong but neat mahogany boxes, with a separate place for each scale, said place being plainly marked, so that any scale can be at once selected. This manner of arranging them is the most practical, time-saving and economical.

THE COMPASS.

A Monthly Journal published the first of every month, at 127 Fulton Street, New York City.

WILLIAM COX, - - - - -	Editor.
KEUFFEL & ESSER CO., - - - - -	Publishers.

SUBSCRIPTION \$2.00 per year, in advance, postage paid. Single Copies, 20 Cents each.
CORRESPONDENCE should be addressed to the Editor of *THE COMPASS*, 127 Fulton Street, New York City.

All such bearing upon the topics to which the Journal is devoted, will be thankfully received and acknowledged with pleasure.

CONTENTS.

	PAGE.
Engineering and Surveying Instruments, - - - - -	49
Speedy Calculators, - - - - -	52
Linear Measurements in the Office, - - - - -	53
Series of Numbers with Examples of their Practical Application to Scientific Purposes	56
Blue Process or Heliographic Paper, - - - - -	60
The Duplex Slide Rule, - - - - -	63

SERIES OF NUMBERS WITH EXAMPLES OF THEIR PRACTICAL APPLICATION TO SCIENTIFIC PURPOSES.

(Continued.)

IF WE NOW TAKE a series of numbers in Arithmetical Progression as shown in our first Article, page 10, and place underneath it a similar series, but in reversed order, that is, with the zero on the right, and progressing towards the left, thus

0	1	2	3	4	5	6	7	8	9	10
10	9	8	7	6	5	4	3	2	1	0

we see that the *sum* of all coinciding numbers is the same, namely 10, and the two similar numbers which coincide, or 5, are the Arithmetical Mean of the two extremes 0 and 10, seeing that $\frac{10+0}{2} = 5$.

So likewise if we place the first series as above, and the second one underneath it so that 10 shall coincide with 2, 9 with 3, and so on, then again the sum of all coinciding numbers is the same, namely 12; and that number of one series which coincides with the same number of the other series, or 6, is the A. Mean of the two extremes 2 and 10. But not only

is 6 the A. Mean of the two extremes, but it is also the A. Mean of all the other coinciding numbers as 9 and 3, 8 and 4, 7 and 5.

Now if we take the series of numbers in Geometrical Progression, as also shown in our first article, page 10, and place a similar series under it, but in reversed order, that is, with the initial 1 on the right, and the series progressing toward the left, thus,

1	2	4	8	16	32	64	128	256	512	1024
1024	512	256	128	64	32	16	8	4	2	1

we see that the *product* of all coinciding numbers is the same, namely 1024; and that number of one series which coincides with the same number of the other series, or 32, is the Geometrical Mean of the two extremes 1 and 1024, seeing that $\sqrt{1 \times 1024} = 32$.

So likewise if we place the first series as above, and the second series with 1024 under 4, 512 under 8 and so on, then again the product of all coinciding numbers as 256 and 16, 132 and 32, etc., is the same, namely 4096; and that number of one series which coincides with the same number of the other series, is the G. Mean of the two extremes 4 and 1024, seeing that $\sqrt{4 \times 1024} = \sqrt{4096} = 64$. But not only is 64 the G. Mean of the two extremes, but it is also the G. Mean of all other coinciding numbers, as 512 and 8, 256 and 16, etc.

It will be found on examination that these same properties belong equally to the scale of a Slide Rule, as shown in Fig. 2, page 38.

A very familiar illustration of the use of this equality of the products of all coinciding numbers, when the slide of the Slide Rule is *inverted* (that is, turned round end for end, so that the figures shall be in reversed order, the initial 1 being on the right, and the scale progressing toward the left) is furnished in the case of two pulleys or wheels, one transmitting motion to the other, and in which their diameters or the number of their teeth are inversely proportionate to the number of their revolutions; and the products of their diameters or the number of their teeth with their respective number of revolutions, are always equal. For instance, suppose a 40 inch pulley, making 36 revolutions a minute drives another one 60 inches diameter, what will be the number of revolutions of the latter? We have therefore

$$\text{Diam}^{\dagger} \text{ Driving} \times \text{Rev}^{\text{ns}} \text{ Driving} = \text{Diam}^{\dagger} \text{ Driven} \times \text{Rev}^{\text{ns}} \text{ Driven},$$

$$\text{or } 40 \times 36 = 60 \times x \text{ whence } x = \frac{40 \times 36}{60} = 24.$$

We can of course solve this with the slide in its ordinary position, but with the slide inverted we are enabled to see at a glance the corresponding number of revolutions of any other diameter of wheel, as all coinciding

numbers on the slide and on the rule are likewise equal to 40×30 or 1440, such as 48 and 30, 45 and 32, 72 and 20, etc.

Lever's are another instance of the same equality of products, as

Long Arm $\times$ Power applied = Short Arm $\times$ Power transmitted.

From the above, it will, we think be clear that it is often advantageous to solve certain problems on the Slide Rule with the slide inverted, the chief advantage being that we see at a glance all the various *combinations of factors* producing a given result, which cannot be done with the slide in its ordinary position.

If we now set the slide of a Slide Rule, so that its initial 1 on the left hand, or the *left index*, as it is called, shall coincide with 2 on the rule, as shown in Fig. 3, page 38, then that number on the slide which coincides with the right index of the rule, or 5, is the *reciprocal* of 2. It is requisite of course that this 5 have the decimal point prefixed to it, which results from the usual arithmetical operation of $1 \div 2 = .5$. and which is also evident when the ordinary rules for the "position of the decimal point" are taken into account. It is therefore clear that any figure on the slide which coincides with either index of the rule, is the reciprocal of the figure on the rule which coincides with either of the slide indices.

Now if we "invert" the slide, each figure on the rule is also the reciprocal of its coinciding figure on the slide, and vice versâ. We thus find 5 coincide with 2, 4 with $2\frac{1}{2}$, 3 with $3\frac{1}{3}$, and so on, so that .2 is the reciprocal of 5, .25 of 4, .333 of 3, also .5 is the reciprocal of 2, .4 of 2.5, and .3 of 3.33.

It is clear from what precedes, that two numbers can be multiplied together on the Slide Rule, with the slide inverted, by placing one factor on the slide opposite (against, or over) the other factor on the rule, and reading off the product on the rule against (opposite or under) either of the indices of the slide. The reason of this is, that according to the ordinary methods of Slide Rule multiplication and division, that is, of adding or joining on to a given distance or number of spaces, another distance or number of spaces, or of subtracting from a given distance another distance, we are now performing an operation of division, the divisor being the reciprocal of one of the factors: thus $8 \times 2 = 16$. With the slide inverted we make 8 on the slide coincide with 2 on the rule, and we read off the product 16 on the rule under the left index of the slide. Now the position of 8 on the slide, or its distance from the index is identically the same as the distance of .125, the reciprocal of 8, from the index, so that we have in reality subtracted the distance .125 from the distance 2, which is equivalent to $2 \div .125 = 16$, with the slide in its ordinary position.

We have shown that in the working out of a certain class of formulæ it is particularly advantageous to make use of the inverted

slide; so also it is often convenient to make use of the reciprocal of a number either for the purpose of multiplication or division. This is especially the case when we wish to obtain the solution of a formula, one of whose elements is a fixed constant. Thus, let it be required to solve the equation $a \times b \times c = x$, in which c is a fixed constant. We have stated that the principle underlying the solution of all arithmetical computations by means of the Slide Rule is that of proportion or equal ratios. The above equation is however not a proportion, but it becomes one, if we substitute for c its reciprocal r . We now have $\frac{a \times b}{r} = x$, the equal ratios being $r : a$ and $b : x$, or we have $a \times b = r \times x$, which can be solved in the same manner as the formulæ for pulleys and levers, that is to say, with one operation instead of three which would have to be effected in the ordinary way with three factors. If this formula is solved with the slide inverted we can see at a glance all the different combinations of a and b , which would produce the same result or value of x .

We will close with a practical example. What head of water, and what volume of discharge is required to produce a force of 20 Horse Power? The formula is

$$H. P. = \frac{\text{Head in feet} \times \text{Discharge in cub. feet} \times 62\frac{1}{2} \text{ lbs.}}{33000}$$

which is equivalent to $\frac{H \times D}{530}$. From this we obtain

$$HP \times \text{Constant } 530 = \text{Head} \times \text{Discharge.}$$

We therefore with the slide inverted make the Horse Power 20 to coincide with the fixed constant 530, then all coinciding numbers on the slide and on the rule give us the different Heads and Discharge which will produce 20 Horse Power;—such as 40 feet head and 265 cub feet of Discharge, 8 feet head and 1325 cub. feet, 200 feet head and 53 cub. feet, etc.

It must be noted that all these remarks and examples apply to the MANNHEIM Slide Rule, in which the upper scales of the rule and the slide, or A and B, are alike, and the lower scale of the rule and the slide, or C and D, are also alike. This form of Slide Rule, which is the best known up to the present, was invented by Mannheim, an officer of Artillery at Metz. From the figure, page 37, it will be seen that the scales C and D are but one complete scale from one end of the rule to the other, while the scales A and B are each composed of two scales, so that the numbers of the two upper scales are the squares of their coinciding numbers of the lower scales.

(To be continued.)

BLUE PROCESS OR HELIOGRAPHIC PAPER.

OBSERVATIONS RESPECTING ITS MANUFACTURE AND PREPARATION.

BY A CONTRIBUTOR.

THERE ARE MANY different ways of preparing a solution for blue print paper, but few of them answer the purpose perfectly. Almost any mixture of Prussiate of Potash and Citrate of Iron, dissolved in water and spread on a sheet of paper will give some result if used shortly after drying, but the preparation of a sensitive paper which will fully answer its purpose, and retain its sensitiveness for any length of time, depends upon the careful selection of the chemicals, the proper kind of water used and, perhaps even still more, on the kind and quality of the paper employed. There are only a few manufacturers who are able to produce a really first-class article for this purpose. Until recently a French paper, largely exported to the States, was considered by many as the best, but it has long since lost much of its reputation. It is a smooth, over-calendered, over-bleached paper, and while medium results are easily obtained with it, its defects make it impossible to secure really first-class results.

A perfect Blue print paper should possess the following qualities:—

1. It should be made of such materials and in such a manner that it will stand a considerable amount of washing, and will not tear when moist, or when wet prints are being handled, and will be strong when dry.
2. It should also be made of such materials and in such a manner that the shrinkage after drying will be uniform and as slight as possible so as not to alter the scale of the drawing or distort it.
3. It should not be coated too heavily with the solution as otherwise the bath, in which the prints are afterwards washed, will become dirty and useless after a few prints have been thus treated, while there is no gain in intensity or permanency of the prints.
4. It should wash easily and quickly, i. e. the chemicals unaffected by the light should be quickly removed in the bath, and those which are reduced by light, should quickly turn into a deep blue.
5. It should give a sharp and distinct reproduction of the original; even the finest lines should appear with the greatest distinctness.
6. It should keep these printing qualities for from 6 to 8 months if properly kept and stored.

We leave it to those who have had occasion to use various kinds of Blue process paper, to judge for themselves, how far these have answered the above requirements. We believe we do not exaggerate when we affirm that almost every consumer has been already imposed upon by some one cheap paper or other, seeing that there are so many people, who think

that spreading a solution of Prussiate and Citrate on any kind of paper will produce a serviceable Blue print paper.

The proportions of the different ingredients for a first class Blue print paper are to-day still a secret possessed by but a few. Persons to whom chemistry is an unknown field or who rely on published formulæ will never succeed in finding a receipt which will yield desirable results. But the mixing of the proper number and kind of chemicals, the right qualities and the proper quantities, are not the only factors required for success ; the paper to be used and the way of treating it are of equal, if not of still greater value.

A certain measure of success is more easily obtained by spreading a poor solution on a perfect paper, than by covering a poor paper with the best solution.

In regard to the paper itself, we abstain from saying anything about strength and thickness, as these depend on the purpose for which the copies are to be used. It is, however, well to emphasize that not every kind of paper, whether perfect for other purposes or not, is a suitable Blue process paper. Paper for this purpose must have all the requirements already mentioned, and must be made of the best stock, be free from every trace of deleterious chemicals and be *sized in a peculiar manner*. The combination of these qualities is not necessary for any other kind of paper, whether for writing, drawing or printing. Paper for Blue process prints is however a specially and peculiarly manufactured article, and a very few makers, prompted by the desire to produce not only a serviceable but the very best article possible, have made a thorough study of the means of obtaining the desired results ; its manufacture is consequently a speciality.

Nearly all makes of Blue print paper in the market are calendered and even over-calendered, because this is the easiest and cheapest way to make them serviceable for the purpose, although it injures the fibre of the paper, helps it to shrink unevenly after washing, and interferes with the distinct rendering of the most delicate parts of the drawing. In calendering, i. e. passing the continuous paper through a series of heavy rollers, the paper is naturally strained, its fibre is crushed and consequently its original strength is destroyed. A greater drawback is that the paper, owing to this artificial compression and the consequent reduction of its strength, will as a Blue print paper swell more in the bath and naturally contract both more and more unevenly when drying, and thus not fulfil what according to ¶ 2 is a very essential feature. Furthermore the calendering gives the paper a smooth and glossy surface, by *destroying the natural surface*. Through the excessive pressure, the original *hard* and *solid* surface of the paper is rolled down to a smooth but somewhat spongy surface. In preparing such pa-

pers with the Blue process solution, the "rolled down" fibres rise by the moisture to a slight but still observable extent. As therefore a calendered paper will never be as smooth after being prepared as it was before, it is clear that when prints on such prepared paper are placed in the bath, and kept there 5 or 10 minutes or, as is often the case, much longer, the calendered surface will rise still more.

It is therefore evident that A PAPER WITH ITS NATURAL MACHINE SURFACE IS FAR SUPERIOR TO ANY SMOOTH, CALENDERED OR HOT-PRESSED PAPER.

Let us now try to explain why very nearly all the makers calender their paper. We can find but two reasons. In the first place it is an old prejudice that photographs must be made on a highly glazed paper to be sharp and good looking, and Blue prints being also a kind of photograph, had in the mind of these makers to be also made on smooth paper. If this reason is accepted, the fact is overlooked that the glazed surface of photographs is unavoidable because all papers used for this purpose had, in order to hold the gold or silver, to be covered with gelatine or albumen, which is smooth and glossy in itself. Since the invention of Professor Willis' platinum process, however, coating with albumen or gelatine is not only unnecessary but is considered injurious to the photographic picture, and the best and handsomest photographs known to science to-day are printed on a slightly grained paper. The second reason why calendering is resorted to is the extreme difficulty that there is in making paper which shall possess throughout the same uniformly grained surface that is necessary. If any slight defect in the surface of the paper exists, it does not show after calendering and no very great care and attention is necessary in making the paper. A poorly made paper can be calendered and made to look like a good article, but the calendering process can never make it a really good one.

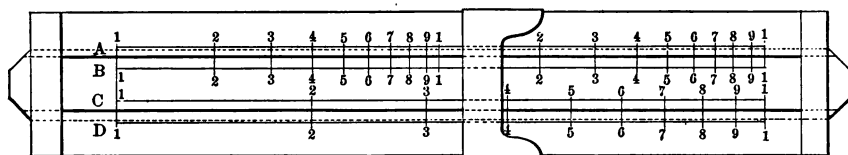
It may be said that a smooth and glossy surface can be brought into much closer contact in the printing frame with the tracing to be copied. This is perhaps theoretically true, although in practice it is not so. Even if it were true in practice, this advantage would be fully counterbalanced by the fact that calendered paper will swell and become rough in the bath *after* the print is made upon it, so that no really sharp lines are possible.

There is not much to say about the coating of the Blue print paper with the chemical solution. It is evident that this must be done by machinery to be uniform and even. All spreading by hand with a sponge or brush can never be satisfactory as the covering will be necessarily streaky and uneven, and as the solution is in constant contact with the brush or sponge and fingers, it will soon become dirty. Every large maker has specially constructed machinery for preparing the paper both in large or small

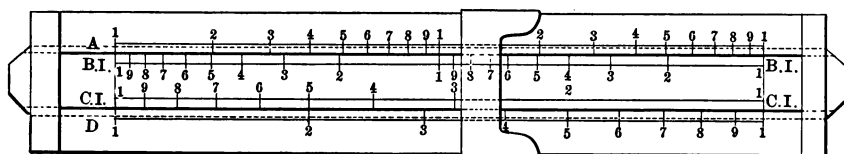
rolls, from which sheets of any size are cut. Large consumers of Blue process paper used to prepare their paper themselves in sheets, but this practice has greatly lost in favor, as ready prepared paper of good quality is now sold at such low prices, that it hardly pays to undertake this unclean business one's self.

THE DUPLEX SLIDE RULE.

Patented October 6th, 1891.



Upper Face.



Under Face.

WE HAVE IN our article on "*Series of Numbers*" shown the great advantages obtained with the Slide Rule in the solution of certain mechanical and other formulæ, by making use of the inverted slide. It will be clear that if we had a Slide Rule combining a slide in its ordinary position, and another slide in inverted position, that is with the initial 1 on the right hand, and the scale progressing towards the left, we should be able to solve many complicated problems with much greater facility and with fewer operations.

The consideration of this subject has led to our taking out a patent for a new Slide Rule called the DUPLEX, which possesses the merit of showing at the same time the slide in its ordinary and in its inverted positions, so that the various kinds of computations referred to in the above article may be much more promptly solved than with the ordinary rule, and also of showing at once all the various factors which would produce a given result.

The patent DUPLEX SLIDE RULE is similar to an ordinary *Mannheim*,

the difference being that the slide itself is of the same thickness as the rule, and has consequently, its two faces flush with those of the rule. The under side of the rule is also graduated like the upper face, and the under face of the slide is also graduated like the other one, but in reversed order, the initial 1 being on the right, and the scales progressing towards the left. The two bars forming the rule are kept together by two metallic cross-pieces at each end, and all the indices on both sides of the rule and slide coincide with each other. A runner, which encircles the whole rule, enables any other coinciding points on any of the scales of the two faces to be at once noted.

We have therefore a Slide Rule, with the scales in the usual order of progression on the one side, and the scales of the slide on the other side in reversed order, so that we are enabled to work out our computations in the way which may be most desirable, or, in the case of a formula involving several factors or divisors, to use the two faces alternately. Thus, let it be desired to solve the equation $a \times b \times c = x$, in which $a = 3$, $b = 4$ and $c = 5$. We first set the factor a on scale C Inverted of the under side of the slide against b on scale D on the under side of the rule, which gives us the product 12 of these two factors on scale D under the left index of the slide. Turning now the rule over, we again find the left index of the slide opposite to 12 on scale D of the rule, which is the position to which we should place the slide if we wished to multiply 12 by any other factor in the ordinary way. Looking therefore on the rule, we find 60 on scale D opposite to 5 on scale C of the slide, which is the product of 12×5 , and also consequently the product of $3 \times 4 \times 5$. This we should demonstrate as follows:—

Slide C Inv ^d		Set 3		C		Under 5
Rule D		To 4		D		Find 60

This multiplication of the three factors has therefore been effected with one operation instead of three as necessitated by the ordinary Slide Rule, thus:—

C		Set 1		Runner to 4		1 to Runner		Under 5
D		To 3						Find 60

Arrangements are being made for placing the DUPLEX SLIDE RULE on the market. As soon as terminated, they will be announced in THE COMPASS.





"COPYRIGHT, 1891, BY WILLIAM COX, NEW YORK."

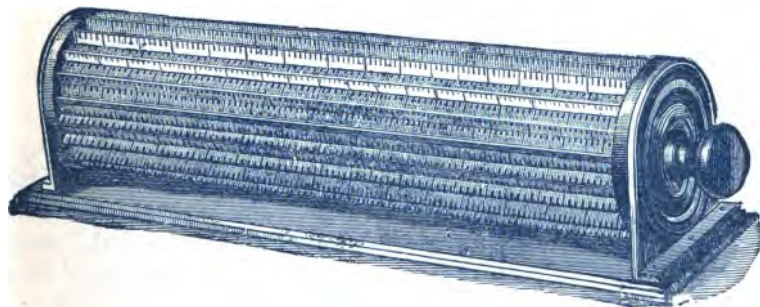
**A Monthly Journal for Engineers, Surveyors, Architects, Draughtsmen
and Students.**

Vol. I.

DECEMBER 1, 1891.

No. 5.

SPEEDY CALCULATORS.



IT NEED HARDLY be said that the principles which determine the graduation of the various Indicators described in previous numbers of **THE COMPASS**, are the same as those which underlie the construction and use of the Slide Rule. This latter instrument is in reality the Universal Calculator, but as considerable space has already been devoted to it in these columns, we shall not further refer to it except to endorse the following recommendation given by Mr. Coleman Sellers in a recent article in the *American Machinist*:—"I would urgently direct the thoughts of "young engineers toward the use of this or similar instruments while they

"have the ability to apply themselves earnestly to the line of study." In the present article we shall consider another class of Calculators, which are, however, but modifications of the Slide Rule.

We have already stated that the limit to the usefulness of the Slide Rule is to be found in its small length. To obviate this objection Mr. Edwin Thacher of Pittsburgh, Pa., has devised another form of the instrument consisting of a metal cylinder 18 inches long and 4 inches diameter, upon which the logarithmic scales are arranged in 20 parallel lines. This cylinder fits closely in an open frame composed of 20 triangular bars which are attached to metallic rings at their ends, admitting of rotation within standards attached to the base. Upon the two exposed faces of each of these bars are found similar scales in close contact with those on the cylinder, so that by means of the rotary and longitudinal movement of the cylinder any line on its surface seen between the triangular bars may be made to correspond with any other line on these latter. In this manner, ratios may be set off as with the ordinary Slide Rule, and all operations of proportion, multiplication and division may be very easily effected. There are two scales on each edge of the bar, the lower ones in contact with the cylinder being the squares of the upper ones, and *vice versa*.

By the arrangement described, the scales are respectively 60 and 30 feet long, and will give results correct to four, and usually to five places of figures, which is close enough for all ordinary business and professional requirements. The ordinary 10 inch Slide Rule is generally considered to give results with an accuracy of 1 in 500. The knowledge of the use of the THACHER CALCULATING INSTRUMENT is acquired in a few minutes by anyone acquainted with the ordinary Slide Rule methods.

Mr. George Fuller, M. Inst. C.E., has also brought out an instrument in which he seeks by another method to increase the length of the scale. His SPIRAL SLIDE RULE consists of a cylinder that can be moved up and down upon, and turned round, a sleeve which is held by a handle. Upon this cylinder a single logarithmic scale is wound in a spiral. An index or pointer is fixed to the handle, while another index is fixed to an axis which slides in the sleeve like a telescope tube, and thus enables the operator to place these indices in any required position relative to the cylinder.

When the fixed index is set to a given number on the cylinder, and the movable index to another one, a ratio is established; if the cylinder be now turned round, thus bringing any other number to the fixed index, the fourth term of the proportion will be shown by the movable index. Mr. Fuller claims that the setting and reading being performed by indices, and not by scale against scale, is a great advantage. We are unable to agree with him in this, because, when the settings are made, as in the case

of the ordinary Slide Rule or the Thacher Calculating Instrument, with scale against scale, we have at sight complete series of equal ratios, which are often very useful and save a great amount of labor, caused by turning the cylinder round every time the third term of the proportion is changed. The use of indices also necessitates three separate operations for a simple multiplication or division, instead of one with the ordinary Slide Rule. Continued use of the Spiral Slide Rule will also we fear be found wearisome, as the instrument, which is somewhat heavy, has to be held in the left hand.

The scale of the Spiral Slide Rule is nearly 42 feet long, which enables numbers of four figures to be accurately set, and results read to as many places.

We must not omit to state that the Thacher Calculating Instrument can be used with the cylinder inverted, just the same as the slide of the ordinary Slide Rule.



CELLULOID.

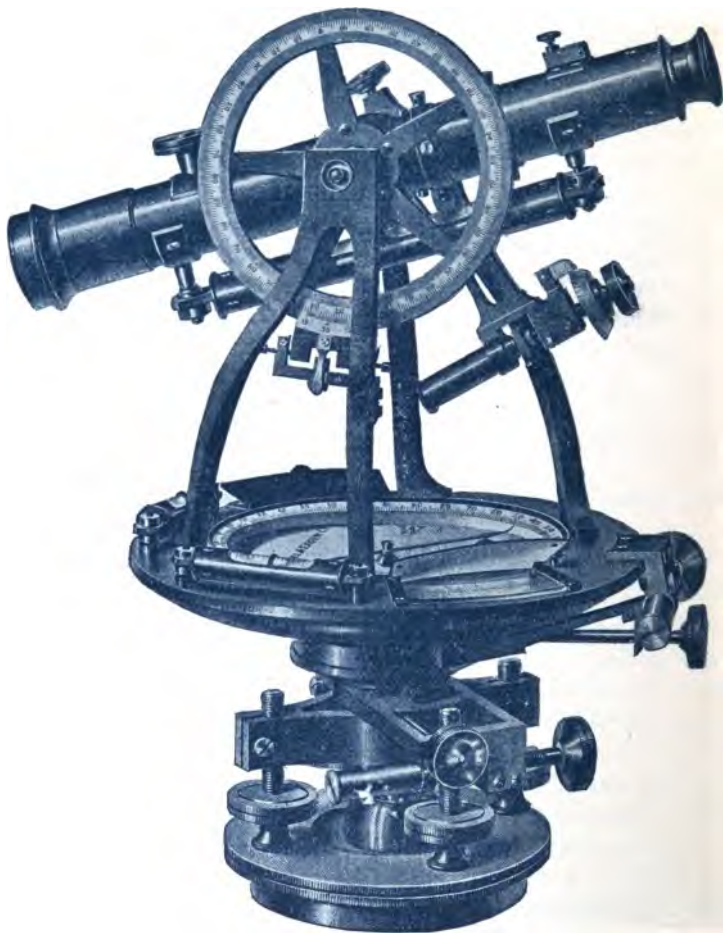
SINCE WRITING the article in our last number on Linear Measurements, we have come across the following paragraph in a recent number of a Washington contemporary:—

“It (celluloid) has also been used for making rulers, set squares
“and other similar instruments of precision, for it has been shown
“that the expansion of this substance is much more regular and uni-
“form than that of wood, and that errors previously unavoidable, can
“be eliminated by its use.”

Notwithstanding the respect we feel to be due to our contemporary, we regret that we are compelled to dissent from the above statement, as our experience has abundantly proved that it has been found impossible up to the present time to produce celluloid goods which do not vary considerably in degree and also with much irregularity. Scales, protractors and other instruments, when intended for accurate work, should therefore be only used with constant attention to their correctness. There is no doubt that instruments made of this material are both neat and cleanly, and possess the advantage of being transparent, thus enabling the draughtsman the better to see the work upon which he is occupied. We can therefore only account for their present popularity in this country on this ground and not by reason of their being superior to wooden ones; in Europe they are no longer accorded the same marked favor. The application, however, of celluloid to wood, when made perfectly homogeneous with it, as in the case of PARAGON scales, is however a step in the right direction, which will, we are sure, be duly appreciated by all those who try them.

*ENGINEERING AND SURVEYING INSTRUMENTS.**(Continued.)*

THE PLAIN TRANSIT.



THE PRINCIPAL PARTS of a telescope used for surveying purposes are the object-glass, the eye-piece and the cross-hairs, with their mountings. The object-glass, composed of two lenses, is mounted in a suitable manner in a tube *B*, Fig. 1, which can be carried in or out of the main tube *A* of the telescope, and adjusted to suit the distance of the object viewed. The tube *B* is maintained in a constant position relatively to the optical axis of the instrument by means of two annular bearings of German silver, rigidly attached to the main telescope tube, through which it slides. These

bearings being fixed, and accurately centred, no adjustment of the objective is required to ensure the line of collimation being correct, whatever may be the distance of the object sighted. By the use of two different metals for the tube *B* and the bearings, friction is reduced to a minimum.

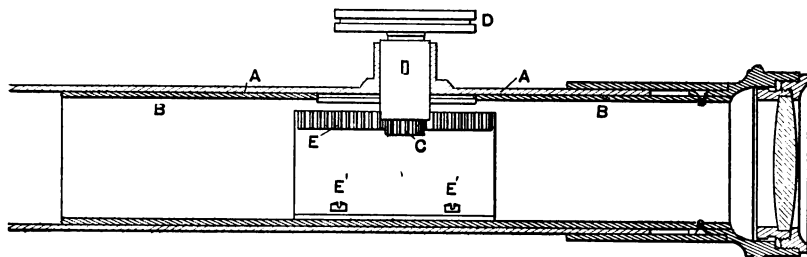


Fig. 1. Patented December 3, 1889.

The focussing of the object-glass for distances is effected by means of a pinion *C* with a milled head *D*, working in a rack *E*, mounted within the interior of the inner tube; but in the transits now being described, this rack, instead of being fixed rigidly to the tube, as is usually done, is connected with it by a peculiar spring *E'* in the form of a semi-tube of hard brass, which is fixed to the inner tube by screws on the side opposite to the rack. This semi-tube lies sufficiently within the interior of the tube, and is so curved, that it may act as a spring, so that the rack will yield somewhat, thus allowing of a nice contact of the rack with the pinion being maintained, even when the teeth of each are worn to an appreciable extent by constant use; it also ensures at all times a smooth and steady sliding motion being imparted to the inner tube containing the object-glass. This arrangement of the rack further allows for the unequal action of the teeth at different periods of their engagement and disengagement, as also, obviously, for any slight irregular movements which may be due to want of absolute perfection in the original forms of the parts. The length and thickness of the spring are sufficient to so engage the rack and pinion, that the longitudinal motion given to the tube shall be always both prompt and complete.

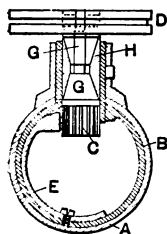


Fig. 2. Patented
Dec. 3, 1889.

To avoid the jarring motion sometimes experienced when adjusting the tube backward and forward to bring it into focus with the object viewed, the pinion is connected by a conical neck *G*, Fig. 2, with the shaft to which the milled head *D* is fitted, the head also having a conical neck *G'*, but in a reverse position to the other one. These two conical pieces, and the small length of shaft exposed between them, are inclosed within a ring of specially prepared fibre *H*, whose inner

face fits the conical parts, while the exterior is cylindrical. A short brass tube, supported in a circular sleeve attached to the main telescope tube, incloses the whole. A small spur on the brass tube, fitting in an open slot in the sleeve, allows the tube to be removed at will, and at the same time prevents it from revolving. The union of the milled head with the pinion shaft is effected by means of a nut, which being screwed up, draws the conical parts together and, consequently, distends the fibrous ring until there is a firm bearing between the different parts, thus preventing all shaking and jarring, and enabling the telescope to be easily and accurately focussed. Should a freer motion be desired, a slight turn of the nut in the contrary direction will give the ease required. The milled head is placed as a rule on the top of the telescope, so as to be conveniently accessible to either hand. The engineer or surveyor will find this arrangement very convenient when he is obliged to take his telescope to pieces for the purpose of cleaning it, as, thanks to the compensating spring, the pinion can be put back in its place, without regard being had to the particular teeth of the rack and pinion which were previously engaged together.

The eye-piece is centred in the usual manner by means of an adjusting ring, *A*, Fig. 3, and capstan-headed screws, but the front bearing ring

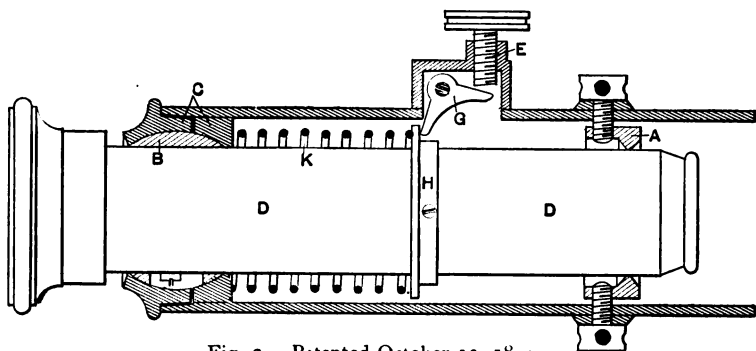


Fig. 3. Patented October 13, 1891.

B, through which it is shifted backward and forward, to bring the cross-hairs into focus, is spherical on its outer surface, the outer bearing *C*, attached to the main tube of the telescope, being also made to correspond on its inner surface, after the manner of a ball and socket joint. The optical axis of the telescope may consequently be made to coincide with the intersection of the cross-hairs without in the least degree straining the eye-piece or the main tube of the telescope. This ball bearing is not necessary, however, when the micrometer adjustment of the eye-piece, now to be described, is used, as there is no straining of the parts as is the case when the eye-piece is simply pulled out and pushed in.

The ocular or eye-piece is focussed by means of a new and patented contrivance which permits of the adjustment being made with the greatest nicety. The tube of the eye-piece *D* is perfectly cylindrical, and the two bearings *A* and *B*, therefore, fit it accurately, so that it is held steadily, but can be adjusted longitudinally without disturbing the optical axis of the telescope. This adjustment is effected by means of a screw *E* with a milled head, placed for convenient access on the top of the telescope. This screw acts upon the horizontal arm of a bell-crank lever *G*, the lower vertical arm of which bears against a ring or collar *H* on the eye-piece. The screw, when turned in one direction, acts on this collar, and moves the eye-piece outward through the bearing rings, while if turned in the opposite direction, the pressure on the lever is withdrawn, and the ocular is gently brought back by a spiral spring *K*, fitted round the eye-piece, and pressing upon the collar *H* and the fixed outer bearings *C*. This arrangement allows of very nice adjustments being made, and overcomes the objectionable features of the ordinary rack and pinion.

Insignificant as these different points may seem, their value will be fully recognized when an instrument has been used some time. In a poorly constructed transit or level, easy and accurate adjustments would then be almost impossible, and poor work would be the natural consequence. It is only by examining such details of construction that we are enabled to judge of the general merits of an instrument, because if sufficient care is not bestowed upon them, it might be rightly presumed that due attention has not been paid to other and more important parts. They are the little straws which indicate which way the wind blows.

Eye-pieces of telescopes for transits and levels are of two kinds :—terrestrial, in which the object viewed, is seen erect, and astronomical, which produce an inverted image. The latter, which is composed of two lenses, although it inverts the object, has the great advantage of illumining it better than the erecting eye-piece, and consequently producing a more distinct image; the field of view is also larger. The terrestrial telescope on the other hand, requiring an eye-piece of four lenses to produce an erect image, entails a loss of light and a diminished field of view. A difference of opinion exists in this country as to whether the superior brilliancy and clearer definition obtained are not counterbalanced by the inconvenience of the object viewed being presented upside down. In Europe, the inverting eye-piece is the one generally preferred, and we believe that a little practice would render its use in almost all cases both easy and preferable.

(To be continued.)

THE COMPASS.

A Monthly Journal published the first of every month, at 127 Fulton Street, New York City.

WILLIAM COX, - - - - -	Editor.
KEUFFEL & ESSER CO., - - - - -	Publishers.

SUBSCRIPTION \$2.00 per year, in advance, postage paid. Single Copies, 20 Cents each.
CORRESPONDENCE should be addressed to the Editor of *THE COMPASS*, 127 Fulton Street, New York City.

All such bearing upon the topics to which the Journal is devoted, will be thankfully received and acknowledged with pleasure.

CONTENTS.

	PAGE.
Speedy Calculators, - - - - -	65
Celluloid, - - - - -	67
Engineering and Surveying Instruments, - - - - -	68
Series of Numbers with Examples of their Practical Application to Scientific Purposes	72
Is the Mariner's Compass a Chinese Invention? - - - - -	76
The Pantograph, - - - - -	77
The Duplex Slide Rule, - - - - -	80

SERIES OF NUMBERS WITH EXAMPLES OF THEIR PRACTICAL APPLICATION TO SCIENTIFIC PURPOSES.

(Continued.)

IT MAY BE ASKED by some why we have devoted so much space to the consideration of the Slide Rule:—to which we reply, that this instrument is in reality a *UNIVERSAL CALCULATOR*, which is useful alike to the Merchant and to the Manufacturer, to the Mechanical as well as to the Civil Engineer and Surveyor, and is consequently worthy of being carefully studied in order to discover all its capabilities. The only real limit to its usefulness may be said to be its comparatively small length which necessitates the divisions and subdivisions being confined within a very short compass. If a Slide Rule were made 10 times as long as the ordinary ones, then all the present subdivisions could be again decimally divided, and if a rule could be made 20 feet long, then, owing to its increased capacity, we should be able to read off with absolute exactitude numbers of 4 and 5 figures. The knowledge of this fact has led to the invention of the Thacher and Fuller calculating instruments, which we describe in another

article. In the present number we wish to show how the Slide Rule may be made to render effective service to the Civil Engineer and Surveyor.

Many geometrical as well as trigonometrical calculations may be very easily worked out with the Slide Rule, as they consist mainly in the finding of the fourth term of a proportion, such as the circumference of a circle when the diameter is known, the diagonal of a square, the side or the angle of a triangle, etc. In many cases such solutions are simplified by the use of Gauge Points or Equivalents, thus for example, let it be required to find the circumference of a circle whose diameter is 156 feet. This is equivalent to the proportion $1 : 3.1416 :: 156 : x$. As however it is not easy to determine on the rule the exact position of 3.1416 to which the index of the slide should be set, we have recourse in this and similar cases to another ratio which may be equally exact and can be easily and more accurately set, owing to its terms falling upon the actual graduations of the rule and slide, thus doing away with all *estimating* in setting the first ratio of the proportion. The nearest ratio we know which gives diameters and circumferences, and which can be set exactly, is that of 226 to 710 (equal to 3.1415929) which is only too great by 1 inch in 186 miles, whereas the usual ratio of 3.1416 is too great by 1 inch in 7 miles, the exact ratio to 7 decimal places being 3.1415926 ... Our proportion, therefore, now becomes

$$226 : 710 :: 156 : x \text{ or } 490 \text{ feet,}$$

which we demonstrate thus:

$$\begin{array}{l} C \parallel \text{Set } G. P. 226 \mid \text{Under } 156 \text{ Diameter.} \\ D \parallel \text{To } G. P. 710 \mid \text{Find } 490 \text{ Circumference.} \end{array}$$

We thus obtain a complete table of Diameters of Circles on scale *C* of the slide, with their corresponding circumferences on scale *D* of the rule. The following gauge points which all fall upon the actual divisions of the Slide Rule, and are correct to at least 1 in 3000, will be found useful for the solution of other similar geometrical problems.

Exact Ratio.	Gauge Points or Equivalents.
1 to .8862	Set 79 = Diam. of Circle
	To 70 = Side of equal square.
1 to .7071	99 = Diam. of Circle
	70 = Side of inscribed square.
1 to .28209	39 = Circumference of Circle
	11 = Side of equal square.
1 to .22508	40 = Circumference of Circle
	9 = Side of inscribed square.

1 to 1.4142	$70 = \text{Side of square}$
	$99 = \text{Diagonal of square.}$
1 to .7824	$205 = \text{Area of square whose side} = 1.$
	$161 = \text{Area of circle whose diam.} = 1.$
1 to .6366	$322 = \text{Area of Circle}$
	$505 = \text{Area of inscribed square.}$

We will now examine the method of working out a few trigonometrical problems which have special reference to the surveyor's work.

If the slide be taken out, turned over face for face, and re-inserted with the right and left indices corresponding to those of the rule, it will be seen that on its *under* side (which is now the upper one) there are three graduated scales. The upper one, marked *S*, gives the angles corresponding to the SINES on scale *A* of the rule, while the lower one, marked *T*, gives the angles corresponding to the TANGENTS on scale *D* of the rule. The sines on the left scale *A* have the characteristic —1, and those on the right scale *A* the characteristic 0; thus

$$\text{Sine } 2^\circ 30' = 0.0436$$

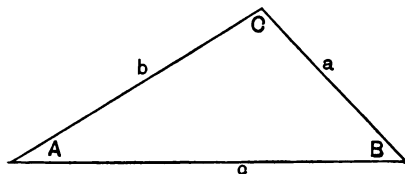
$$\text{Sine } 24^\circ = 0.4067$$

Scale *D* gives directly the tangents as far as 45 degrees only, those for larger angles being found by the formula $\tan a = \frac{1}{\tan (90 - a)}$. Multiplication and division of sines and tangents are executed in the same manner as for ordinary calculations.

The middle scale is one of 500 equal parts, figured from 0 to 1000, and gives the logarithms corresponding to the numbers on scale *D*. It is very useful for obtaining fractional powers or roots, such as $\sqrt{x}$ in Eytelwein's rule for the delivery of water from pipes.

We shall be able to understand the manner of using these scales by considering the general relationship of the sides and functions of angles of triangles, viz:—

The sides of a plane triangle are proportional to the sines of the angles opposite.



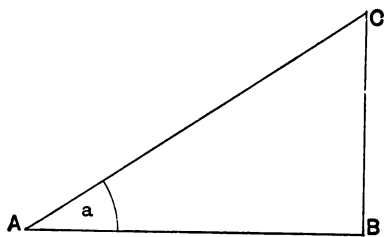
Let *A*, *B* and *C* be the angles of any plane triangle, and *a*, *b* and *c* be the three sides opposite the angles, then we have the following double proportion:—

$$\text{Side } a : \text{Sin } A :: \text{Side } b : \text{Sin } B :: \text{Side } c : \text{Sin } C$$

which we demonstrate thus for the Slide Rule,

A	To Side a	Find Side b	Find Side c
S	Set angle A	over angle B	and over angle C
T			
D			

From this it will be seen at once how easily and quickly we can with the Slide Rule find the remaining sides and angles of a triangle when any three parts (one being a side) are known. This is owing to the principle of equal ratios which underlies the construction of the instrument, which principle is dependent, as has been shown, upon the peculiar properties of



series of numbers in Arithmetical and Geometrical Progression when taken conjointly.

Perhaps the most useful application of this method of solving triangles is that relating to traversing. Let angle $BAC = a$, be the course, and AC be the distance,

then, Latitude $= BC = AC \times \sin a$, and

Departure $= AB = AC \times \cos a = AC \times \sin (90^\circ - a)$.

We set the angle B or 90° on scale S of the slide opposite the distance AC on scale A of the rule, then we find on scale A the latitude BC over the angle a on scale S , and the departure AB on scale A over the angle ACB on scale S of the slide; this angle ACB being the complement of the angle a , or $90^\circ - a$. We demonstrate this thus:—

A	To Distance	find Latitude	find Departure
S	Set 90°	over angle a	over angle $(90^\circ - a)$
T			
D			

(To be continued).

We learn from *The Recorder* that engraving on metal is now carried to a wonderful pitch of excellence, but according to accounts from Russia further remarkable strides are being made in the art in that country. A Russian electrician is said to have devised a process of photographing and engraving on metals by means of electricity, by which the etching method is entirely dispensed with. The process has been patented, and the electrician is understood to be about to take a trip abroad for the purpose of disposing of his invention.

*IS THE MARINER'S COMPASS A CHINESE
INVENTION.*

A WRITER in the *North China Herald* of Shanghai devotes a learned article to detailing and discussing the facts regarding the claim of the Chinese to have invented the mariner's compass. They did not learn the properties of the magnetized needle from any other country. They found it out for themselves, though it is impossible to point to the man by name who first observed that a magnetized needle points north and south. He suggests that it came about in this way:—The Chinese have in their country boundless tracts of ironstone, and among these no small portion is magnetic. Every woman needs a needle, and iron early took the place of the old stone needles, and were commonly used before the time of Ch'in Shih-huang—that is, more than twenty-one centuries ago. Whenever a needle happened to be made of magnetic iron, it might reveal its quality by falling into a cup of water, when it happened to be attached to a splinter of wood, for example. It came in some such way to be known commonly that certain needles had this quality. The great producing center for magnetic iron, is T'szchou, in southern Chihli. This city was very early called the City of Mercy, and the magnetic stone produced there came to be known as the stone of T'szchou, and so *t'szshih* became the ordinary name for a magnet. Later, the Chinese began to speak of the city as the "City of the Magnet", instead of calling it the "City of Mercy". The popularity of the magnetic needle would become known to the Chinese of that city and its neighborhood first. The first who noticed the polarity would be some intelligent person who communicated the fact as an unaccountable peculiarity in an age when omens and portents were diligently sought for in every natural object and phenomenon. The earliest author who mentions the "south pointing needle" lived in the fourth century B. C. There can be no reasonable doubt that the polarity of the needle was known at that time. The discovery of the fact must have preceded the invention of any myth embracing it. As to the discovery, there is no reason to suppose it was in any way foreign, because the Chinese use an enormous number of needles, and have an inexhaustible supply of ironstone. But though the polarity was known, it was not turned to a practical use till the Tsin dynasty, when landscapes began to be studied by the professors of *fengshui* or geomancy. There was at that time a general belief in the magical powers of natural objects. This was a Buddhist doctrine, and it took firm hold on the Chinese mind of that age. The Chinese Philosophers of those times taught that indications of good and ill luck are to be seen all through nature. The polarity of the needle would take its place in this category of thought. Though it is not distinctly mentioned by writers of the fourth century, yet to their disciples

it became an essential part of the landscape compass which the professors of *fengshui* all use. Kwo Pu, the founder of this system, died A. D. 324, and it was not till four centuries later that the *fengshui* compass began to assume its present form. The compass used by the professors of geomancy for marking landscape indication was first made about the eighth century. It was of hard wood about a foot wide, and it had in the centre a small well in which a magnetized needle floated on water. On the compass were inscribed several concentric circles as on the wooden horizon of our globes. They embrace the twelve double hours, the ten denary symbols, eight diagrams and others marks. The compass was used in preparing a geomantic report of any spot where a house or tomb was to be constructed, so that the construction might not be upon an unlucky site or planned in an unlucky manner. At the same time there was living a Chinese who had studied Hindoo astronomy, and was the imperial astronomer, and also a Buddhist priest. He noticed that the needle did not point exactly north, and that there was a variation of $2^{\circ} 95'$. This variation went on increasing till a century later, that is till the ninth century. A professor of geomancy then added a new circle to the compass. On this improved compass the first of the twelve hours begins on the new circle at $7\frac{1}{2}^{\circ}$ east of north. The compass, it will be observed, grew out of the old astrological report or nativity paper, calculated from the position of the stars, and prepared in the Han dynasty by astrologers. In 1122 an ambassador to Corea describes the use of the floating needle on board ship while he made the voyage. This is the first instance, the earliest by more than a century, of the use of the mariner's compass on board ship, found as yet in any book, native or foreign.—*Science*.

THE PANTOGRAPH.

THE PANTOGRAPH IS an instrument specially designed for reproducing drawings on a reduced, enlarged or equal scale. It is well to note, however, that in the latter case every slight deviation from the lines of the original as well as every error caused by imperfect construction becomes magnified, so that its use can only be recommended for the purpose of *enlarging* drawings, when instruments of the greatest precision are employed.

The Pantograph, like so many of the Engineer's aids, owes its usefulness to certain mathematical principles, which will be considered in due course in our articles on "Series of Numbers." The present notice is intended to give a general description of this useful instrument with a few hints as to its use.

Pantographs are of various kinds, but generally consist, as shown in our illustration, of two short and two long arms, so jointed as to form a true parallelogram, whatever may be the position of the outer arms. Two sockets are attached to the long arms, in one of which a pencil is inserted, and in the other one a tracing point. The Pantograph is fixed to the drawing board by means of a fixed pivot or fulcrum, which fits into a brass or iron weight, placed in a suitable position on the board, so that the whole instrument, when being used, may move about this centre. Several castors are fixed to the under sides of the arms, to ensure their motion being easy and steady.



THE PANTOGRAPH.

The Pantograph may be used in two different ways, known as the *Erect* and the *Reverse* methods. In the former, the copy made will be erect, that is, the same way as the drawing, whilst in the latter it is the reverse. This latter method is, however, more generally used, as it enables the original drawing and the sheet of paper on which the copy is to be made, to be placed side by side, without overlapping. The proportions, to which the reproduction can be made are also, as a rule, more suitable, and their range is greater.

Our illustration represents a Pantograph of the most recent construction, accurately made and well finished, so that there may be no jarring in any of the movements. It is intended to reproduce drawings by the reverse method. The fulcrum is fixed to a socket which slides on one of the short arms, while the pencil is placed in the fixed socket of the right long arm when used for *enlarging*, and in the one which slides on the left long arm for *reducing*, the tracer being always placed in the socket of the other long arm. The left long and short arms are graduated, the figures against the divisions denoting the different proportions in which drawings may be reproduced. To set the instrument, the fulcrum and the left sliding socket are each placed to the division answering to the scale of the reproduction required. It should be especially noted, that when all the parts are correctly set, the pencil, the tracer and the pivot in the weight will be points in a straight line.

The following table gives the settings marked on this instrument. Other settings may be obtained as shown further on.

Divisions between each indicated Setting.	Total Number of Divisions from Zero.	Setting.	REDUCES with Pencil in Left arm.	ENLARGES with Pencil in Right arm.
Zero	Zero	6	From 6 to 1	From 1 to 6
2	2	5	" 5 " 1	" 1 " 5
3	5	4	" 4 " 1	" 1 " 4
5	10	3	" 3 " 1	" 1 " 3
10	20	2	" 2 " 1	" 1 " 2
10	30	$\frac{1}{3}$	" 3 " 2	" 2 " 3
5	35	$\frac{1}{4}$	" 4 " 3	" 3 " 4
3	38	$\frac{1}{5}$	" 5 " 4	" 4 " 5
2	40	$\frac{1}{6}$	" 6 " 5	" 5 " 6
4	44	$\frac{1}{10}$	" 10 " 9	" 9 " 10
1	45	$\frac{1}{12}$	" 12 " 11	" 11 " 12
5	50	1	Full Size.	Full Size.

To obtain intermediate Settings, let

x represent the value of the left hand Pencil or Tracer, and

y " " " " " right " Tracer or Pencil,

then

$x:y$ = ratio of copy to original, when the Pencil is in the left arm for *reducing*, that is:—

$$\text{Copy : Original} :: x : y$$

$x:y$ = ratio of original to copy, when the Pencil is in the right arm for *enlarging*, that is:—

$$\text{Original : Copy} :: x : y$$

To obtain the Setting, we have *

$$\left. \begin{array}{l} \text{Setting of Socket} \\ \text{on left long arm.} \end{array} \right\} = \frac{60 \times x}{y} - 10.$$

If for example, $x = 1$ and $y = 6$, the setting becomes $\frac{60 \times 1}{6} - 10 = 0$ (zero), which is the initial point, and is represented by the division marked 6 on the left long arm near the joint. From this point downwards there are 50 divisions which correspond to the Settings obtained by the for-

* The Constants of this formula apply to a 33-inch Pantograph ; for different sizes and makes they may naturally vary.

mula ;—thus to find the Setting to enlarge from 4 to 5, $x = 4$ and $y = 5$, then the Setting $= \frac{60 \times 4}{5} - 10 = 38$. On the 38th division downwards from 6 will be found $\frac{1}{5}$, which means that the original will be $\frac{1}{5}$ th smaller than the copy, or the copy will be $\frac{1}{5}$ th larger than the original, that is:—

Original : Copy : : 4 : 5.

Other settings are found in the same manner. Having thus the two outer points determined, the fulcrum is now moved along the short arm, until it is in a straight line with the pencil and the tracer points.

In the better class of Pantographs a convenient arrangement is provided for raising the pencil point without taking the hand off the tracer, so that any parts of the original may be passed over without the copy being marked. A handle is also often attached to the two long arm sockets so that the tracing point may be moved about both delicately and firmly.

When many straight or curved lines have to be reproduced, it will be found useful to employ a transparent guide, such as a celluloid straight-edge or curve, which the tracer may be made to follow with greater precision.

All Pantographs with sliding sockets are graduated on the same principles as the one described, the only difference in the formula being a variation of the Constants 60 and 10, which may be found in different sizes and makes of instruments.

THE DUPLEX SLIDE RULE.

WE OMITTED to state in our description of the Duplex Slide Rule, in our November issue, that the solution of Trigonometrical formulæ would also be very much simplified by its use, as a duplicate slide will be supplied with the instrument when desired, with the ordinary scales *B* and *C* on one face, and on the other face the scales of Sines, Tangents and equal parts. By turning over the rule, as already explained, such formulæ as $\frac{b \times c \times \sin A}{2}$, giving the area of a triangle, can be very quickly solved, and that without having to take the slide out and reverse the faces, as is necessary with the ordinary Slide Rule. The great advantages of this new form of Slide Rule will, we are sure, commend it to the profession.



"COPYRIGHT, 1891, BY WILLIAM COX, NEW YORK."

**A Monthly Journal for Engineers, Surveyors, Architects, Draughtsmen
and Students.**

Vol. I.

FEBRUARY 1, 1892.

No. 7.

*THE SAEGMULLER SOLAR ATTACHMENT USED
AS A VERTICAL SIGHTING TELESCOPE.*

COMMUNICATED BY G. N. SAEGMULLER.



Fig. 1.

THIS ATTACHMENT to the regular Engineer's Transit, shown in Fig. 1, by means of which the astronomical meridian may be obtained in a few minutes, and that with a degree of accuracy scarcely thought to be possible, is familiar to almost every engineer. It is however only quite recently that it has been recognized as the best Vertical Sighting Telescope, by reason of the

readiness with which it can be attached to the ordinary Transit, and on account of the accuracy of the results obtained.

The construction of the attachment allows the small telescope to be placed in a vertical position, and when so placed, it fulfils every requirement of an instrument designed for vertical as well as oblique sighting in mining work.

In order to use the Solar Attachment for this purpose, proceed as follows : See that the Transit is in perfect adjustment. Point both telescopes horizontal and see that the Solar points as much above the Transit telescope as equals the distance between their axes. When this is the case, the lines of collimation of both telescopes are parallel. Now turn the Transit telescope 90° , as shown by the vertical circle, taking care not to disturb the relative position of the Solar Telescope and that of the Transit, and both will now point vertically downward, as shown in Fig. 2.



Fig. 2.

As the standards of the Solar are made high enough to allow the small telescope to clear the plates, it is evident, that the Solar telescope now points accurately to the Nadir.

The same *modus operandi* holds good when it is desired to obtain an oblique sight, as it is only necessary to set off the desired slope on the vertical circle, after having tested the parallelism of both telescopes.

For very accurate work it is desirable to make the observations in two positions by reversal. By then taking the mean of the two sets of observations, instrumental errors are eliminated.

Our illustration, page 105, shows this Attachment fitted to a complete Engineer's Transit, such as we have described in these columns.



HOW TO DETERMINE THE POSITION OF VANISHING POINTS IN PERSPECTIVE DRAWING.

IT IS A FACT needing no demonstration that objects appear smaller in proportion to their distance from the observer. The near end of a straight wall, for example, 20 feet high and 100 feet long, will appear to any one standing close to it to be that height, whereas the far end, as the observer looks along the length of the wall, will appear very much smaller, and if it were continued sufficiently far in a straight line, would finally va-

nish in a point. As we look cornerways upon a square pile of buildings, so as to take two sides in our view, we note that what are in reality the horizontal lines of the walls, windows etc. appear to slope downwards and away from us on either side, while those of the basement, which are below our eye, seem to rise. If we were to stand immediately opposite the centre of a long straight wall, whose top is perfectly horizontal, its upper edge would appear to us to fall away below a true horizontal line on each side of the point directly opposite our station of observation, whilst the ground line of the wall would appear to rise, until the top and bottom lines on our right and left would disappear in a vanishing point which would be found to be on a level with our eyes.

To reproduce in the form of a drawing any building, so that this tendency of the horizontal lines to vanish or recede toward a given point or points, shall be faithfully represented, is termed PERSPECTIVE DRAWING, and an object so delineated, is said to be in perspective. The question however arises, how can the amount of slope to be given these receding lines be determined.

When anyone sits down and views a landscape, composed in part of a house, church, bridge or other similar building, with the desire to transfer it faithfully to paper in the form of a drawing, the usual course is to estimate, or (as is often the case) guess at the direction of the receding lines, this process being frequently aided by holding the pencil at arms length before the eyes and in front of the object, so as to determine the precise degree of slope. The pencil is now laid on the paper, taking care to maintain at the same time as far as possible its slanting position, and the direction of the lines is then easily noted. This method may suffice in some cases, but will not enable a more or less complicated structure to be faithfully portrayed. When an accurate representation is required, recourse must therefore be had to Vanishing Points, toward which, as pointed out, all horizontal lines, viewed in perspective, must tend. But it may now be asked, how are the *exact* positions of these vanishing points to be determined?

Let it be supposed that we wish to make a drawing of a landscape with a cottage in the foreground, and that the view which is found to be most pleasing is one in which the front recedes from the observer at an angle of 30° , and the end at an angle of 60° , with the ground-line, this *ground-line* being a horizontal line running on the ground to the nearest corner of the building, and being, consequently, parallel with the bottom edge of our sheet of drawing paper as we hold it in position before us. Parallel with the ground-line, but on a level with the eyes is another imaginary horizontal line, called the *line of sight*, and the point on this line directly in front of us is called the *point of sight*. A line proceeding from our *point of observation*,

or *station-point*, to the point of sight, called the *line of direction*, will therefore be perpendicular to the line of sight and the ground-line. All horizontal lines of the building will now be found to meet somewhere on the line of sight in two points, one on the right and the other on the left of the point of sight. These points, called the *Vanishing Points*, will be found to be sometimes near to the point of sight and sometimes a considerable distance from it, varying with the position of our point of observation and with the angle formed by the sides of the building and the ground line, being shorter in proportion as we are closer to the object observed, and also as the angle formed with the base line is greater.

In order to determine the *exact* position of the vanishing points we now measure or estimate the distance from our point of observation to the point of sight, that is, the length of the line of direction, and then work out the following easy formula :—

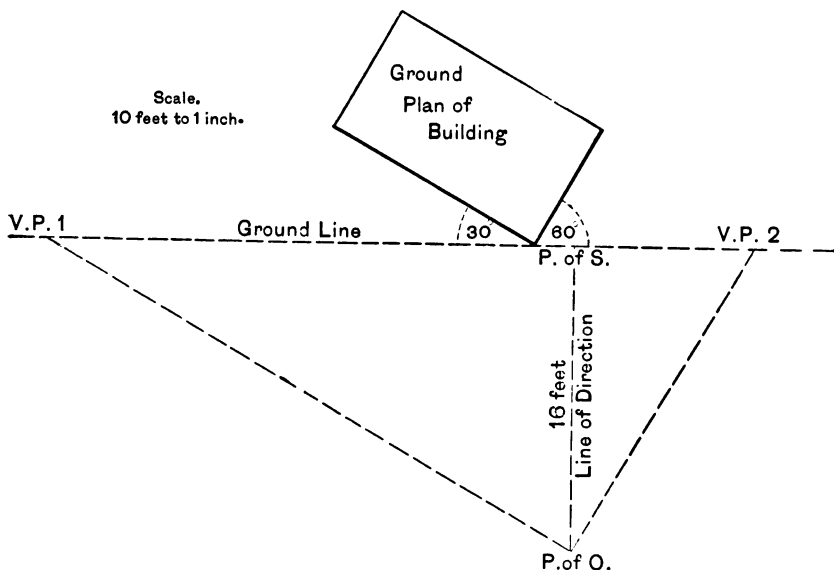
$$\left. \begin{array}{l} \text{Distance of Vanishing Point from} \\ \text{Point of sight} \end{array} \right\} = \text{Line of Direction} \times \text{Cotangent} \\ \text{of Angle,}$$

the angle being, as already stated, the one formed by the ground line and the sides of the cottage. For convenience we give here the cotangents of the different angles from 5 to 90 degrees, advancing by 5° at a time, which will be near enough for all artistic requirements.

Cot 5° = 11.43	Cot 35° = 1.43	Cot 65° = 0.47
10 = 5.67	40 = 1.19	70 = 0.36
15 = 3.73	45 = 1.00	75 = 0.27
20 = 2.75	50 = 0.84	80 = 0.18
25 = 2.14	55 = 0.70	85 = 0.09
30 = 1.73	60 = 0.58	90 = 0.00

The distances thus calculated are the real or actual ones, which now require to be reduced to the scale of our drawing. The same method may be adapted for finding the exact position of the vanishing points when it is required to make a perspective drawing of any building from the plan and elevations of the same, when their distance from the point of sight is so great that they cannot be located on the drawing board. The vanishing line can then be easily and correctly put in by means of the Centrolinead described in *The Compass* for August 1891, the settings of which will be easily found by the formula and table given.

The accompanying ground plan of a small building will sufficiently indicate the method of procedure described.



In the above the

Distance from *P. of S.* to *V. P. 1* = 16 feet $\times$ 1.73 = 27.7 feet.

“ “ “ “ *V. P. 2* = 16 feet $\times$ 0.58 = 9.3 feet.

which, reduced to the scale of 10 feet to an inch, to which the drawing is to be made, give respectively 2.77 and 0.93 inches for the required distances of the Vanishing Points to be set off on the drawing paper, from the Point of Sight.

SPEEDY CALCULATORS.

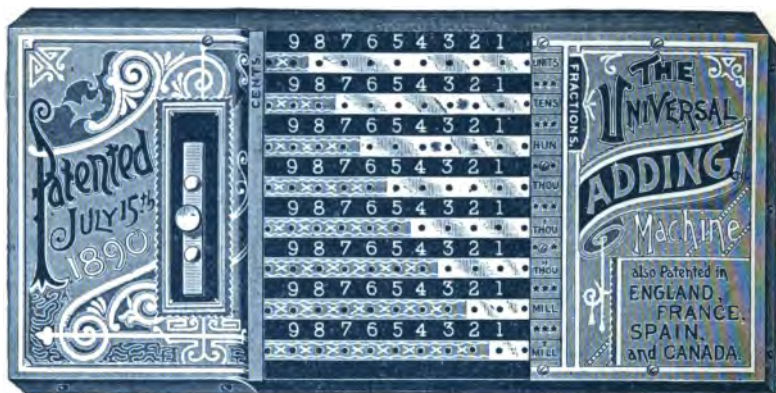
THE INSTRUMENTS for facilitating calculations which we have been examining are all based on certain mathematical principles. We now come to another class, which may be called Mechanical Calculators, as the results are produced by certain mechanical combinations. One of the simplest of these, which will, however, be found very useful in many cases, is the UNIVERSAL ADDING MACHINE, invented and patented by Mr. Geo. B. Fowler.

As shown in the accompanying cut, it consists of an ebonized tablet, $9\frac{1}{4}$ by $4\frac{1}{2}$ inches, having eight silver-plated slides, let into grooves in its face, alternating with rows of numerals, 1, 2, 3, 4, 5, 6, 7, 8, 9 engraved above each sliding bar, one row for each denomination:—units, tens, hundreds, etc., to tens of millions.

The machine is operated by placing a steel pointed stylus in small

holes in the slides under the numbers desired to be added, and moving the bars to the right or left as may be necessary. The result of the addition is shown plainly in the register on the under side of the tablet.

There are two parts to each bar, one plain and one shaded, the plain part always being moved to the right and the shaded part to the left, taking care in both cases that the stylus always strikes the cap, and if the bar has been moved to the left, 1 must be invariably carried to the bar next below. It will thus be clear that the last move should always be to the right.



The method of operating this machine is so simple and self-evident, that it may be learned by anyone in a few minutes, while long columns of 7 rows of figures may be easily added at the same time with an accuracy and dispatch which can only be attained by the ordinary mode after years of constant practice. Its construction is such that it cannot make an error or get out of order, its work being accomplished without the aid of cog-wheels, springs, etc. An important mechanism is provided (shown on the left of the cut) for the purpose of locking the sliding bars in case of interruption before the addition is complete, or when it is desired to preserve a result for further reference,

The capacity of the machine is very great, being one less than one hundred million, or if dollars and cents be added, one less than a million dollars.

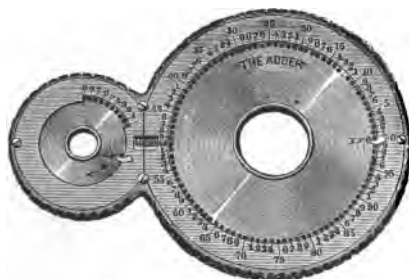
Among its many uses may be mentioned the following :—

For Book-keepers and Accountants,

- “ Lumbermen, in tallying feet and inches,
- “ Weighers, “ “ pounds and ounces,
- “ Dry-goodsmen “ “ yards and fractional parts,
- “ Coal and grain dealers, for all purposes of tallying,
- “ Gauger’s use in distilleries for tallying Government tests.

In all of the above, and other uses, it is a great saver of time and labor, as the sum total is seen at once by the register on the under side, as soon as the last figure is recorded.

A smaller size, $4\frac{1}{2} \times 2$ inches, with six sliding bars, is also made of satin-wood and german silver, so that it can be conveniently carried in the pocket and used for noting purchases or expenses when out shopping or traveling. It may also be had in combination with a cabinet, thus serving as a Cash Register.



Webb's ADDER is another mechanical device intended to facilitate the addition of columns of figures. It consists of two revolving metal disks, the larger one, as shown, having 100 small round holes on its circumference, numbered from 00 to 99, whilst the smaller disk has 50 holes likewise numbered from 00 to 49. The

outer edge of each disk is covered with a cap so that the numbers are only seen through a small slot as the disk is turned round by means of a pointer (which can be put on the end of any ordinary pencil) being inserted in the holes. Opposite each hole, on the cap of the large disk, are similar numbers, whilst those on the cap of the small disk run from 0 to 9. Before using the instrument, each of the disks should be turned round until nothing but zeros show in the slot; this is quickly done by inserting the pointer in the hole 0 marked  on the large disk and turning it in the direction of the hands of a watch, until the pointer is arrested by a small stop attached to the cap opposite 0. The same is then done with the small disk. The Adder is now ready, and two columns at once may be tallied or added on the large disk by putting the pointer successively in the hole opposite each number to be added, and each time turning the disk round until arrested by the stop, thus, 83, 46, 89, 21, turning the larger disk for each of these numbers, when 239 is seen in the slot, the hundreds carrying themselves forward automatically. When there are 4 or more columns to be added, it is necessary to perform the operation in pairs, carrying forward each time the hundreds. The inventor maintains that the Adder is too simple to be called a "Machine," but guarantees it to add with mechanical accuracy and rapidity any number of columns of figures, one, two or three at a time. The adder is of metal throughout, is nicely finished, and is constructed on the "interchangeable" plan, so that parts can be readily replaced if breakage should occur.

THE COMPASS.

A Monthly Journal published the first of every month, at 127 Fulton Street, New York City.

WILLIAM COX, - - - - -	Editor.
KEUFFEL & ESSER CO., - - - - -	Publishers.

SUBSCRIPTION \$2.00 per year, in advance, postage paid. Single Copies, 20 Cents each. *CORRESPONDENCE* should be addressed to the Editor of *THE COMPASS*, 127 Fulton Street, New York City.

All such bearing upon the topics to which the Journal is devoted, will be thankfully received and acknowledged with pleasure.

CONTENTS.

	PAGE.
The Saegemuller Solar Attachment used as a Vertical Sighting Telescope, -	97
How to determine the position of Vanishing Points in Perspective Drawing, -	98
Speedy Calculators, - - - - -	101
Engineering and Surveying Instruments, - - - - -	104
Series of Numbers with Examples of their Practical Application to Scientific Purposes	107
Weather Prognostics, - - - - -	112

ENGINEERING AND SURVEYING INSTRUMENTS.

(*Continued.*)

THE TRANSIT.

WHEN THE TRANSIT is provided with stadia hairs, it is usual to have a long bubble attached to the telescope and a vertical arc or limb to the telescope axis, so that horizontal sights may be taken and angles of elevation or depression measured. This bubble, which is placed on the under side of the telescope is about 5 inches long, of which 3 inches are exposed and are finely graduated, being very carefully tested to ascertain the angle given off by the movement of the bubble through one single division. The level-tube is attached in such a manner that its position may be slightly varied horizontally at the object-glass end, and vertically at the eye-piece end ; by this means its axis may be made to perfectly coincide with the line of collimation of the telescope. The glass tube is carefully ground to a proper arc, graduated and marked each way from the centre, the angular value of one division being generally marked on the end of the level-tube.



As the bubbles are read from the centre to the ends, it naturally follows that half the difference of the readings of the ends of the bubble gives the distance of the centre of the bubble from the zero of the scale.

We have stated that a long bubble attached to the telescope, in addition to its being employed for leveling purposes, may be also used for measuring small vertical angles, thus :—Having carefully read the two ends of the bubble, take half their difference, then, having shifted the telescope vertically as desired, take again half the difference of the readings of the two ends of the bubble. The difference of these two quotients gives the number of the divisions through which the bubble has moved, which, multiplied by the angular value of one division, is the vertical angle through which the telescope has been moved.

This supposes that the centre of the bubble does not pass from one side of zero of the scale to the other side of the zero. Should it so pass, then the sum of the two quotients must be taken, in order that the number of divisions through which the centre of the bubble has traveled may be obtained.

Let us suppose that one division of a bubble scale represents a vertical angle of 27 seconds, and that we have, after sighting, the following readings :

$$\text{Left End } 5\frac{1}{2} - \text{Right End } 13 - \text{Half Difference} = 3\frac{3}{4}.$$

After again sighting, we have

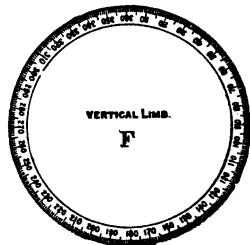
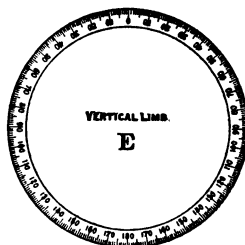
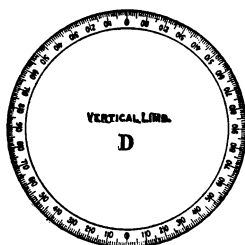
$$\text{Left End } 12 - \text{Right End } 6\frac{1}{2} - \text{Half Difference} = 2\frac{3}{4}.$$

From these readings it is clear that the centre of the bubbles has passed the zero of the scale, so we take the sum of $3\frac{3}{4}$ and $2\frac{3}{4} = 6\frac{1}{2}$, which is the number of divisions through which the bubble has moved, and this multiplied by $27 = 175\frac{1}{2} = 2' 55\frac{1}{2}"$, is the vertical angle through which the telescope has been shifted.

The sensitiveness of spirit levels, which varies according to the radius of curvature of the bubble tube, being more sensitive as this radius increases, should be in proportion to the quality of the instrument. It would

be useless to place a very sensitive level on an instrument which will not read correctly to within 30 seconds, while an insensitive level placed on an instrument capable of, and used for very fine work, would be equally useless. The sensitiveness of the spirit level should, therefore, be in proportion to the accuracy and care bestowed upon the construction of the transit, to the power of the telescope, and to the graduations of the limbs, so that when these are all of the highest order, the instrument may be relied upon, in all its parts, as being capable of doing fine work. Sufficient time must always be allowed for the bubble to be perfectly settled before taking readings. It will be found that a long air-bubble will settle more quickly and more uniformly than a short one.

In all cases where angles of elevation or depression have to be taken, it is necessary to have either a graduated vertical arc or limb (complete circle). The latter, shown in our illustration, is naturally the more useful, as by it, errors of eccentricity and inaccuracies of the graduations may be eliminated by reversing the telescope and revolving the top plate 180 degrees, then reading the vertical angle again and taking the mean of the two readings. The circle is usually graduated to half degrees, reading by means of a vernier to single minutes, or else graduated to 20 minutes and reading to 30 seconds; still finer graduations being, of course, made when required. These graduations are generally numbered as shown by Figs. D, E and F.



The vernier, which is fixed to the standard, is adjustable laterally so that it may be made to coincide with the line of collimation of the telescope, after the axis of the telescope bubble has been brought parallel with the line of sight, that is to say, that the vernier index may coincide with the zero (or 180) of the limb. The vernier itself, which usually reads both ways, is hinged on pivots, so that it can be lifted from the graduated circle by a small lever, when the telescope is being brought into position, thus preserving the delicate silvered surface of the limb. The limb itself, which is reinforced by a strong rib, is not divided up to its edge, as the least shock to the circle would impair the graduations and render accurate readings impossible.

As it is necessary when measuring vertical angles by means of the vertical limb or with the spirit level, to be able to revolve the telescope with great precision and accuracy, a clamp is attached to its axis, which, when screwed up, holds the telescope firmly in any desired position. Further accurate adjustment may then be obtained by means of a micrometer tangent or slow-motion screw, with opposing or compensating spring, attached to the standard. All these various accessories are clearly shown in the illustration of our January number, page 84.

When it is required to take greater vertical angles than would be convenient with the ordinary eye-piece, a diagonal prism is provided, similar to the one shown in Fig. 1, page 97. This prism is attached to the cap of the eye-piece, so that the object sighted is diverted to the eye when held at right angles to the telescope. A darkened glass can also be made to slide over the prism when the telescope is directed to the sun. The object glass of the telescope is provided with a dust shade, so that when it is pushed out to its extreme limit, no dust or dirt can enter between the sliding parts and affect their carefully adjusted surfaces. A sun shade is also provided to prevent the sun's rays falling upon the objective.

(To be continued)

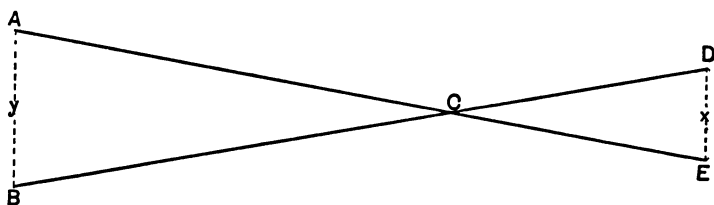


SERIES OF NUMBERS WITH EXAMPLES OF THEIR PRACTICAL APPLICATION TO SCIENTIFIC PURPOSES.

(Continued.)

WE HAVE ALREADY shown that when the values of two quantities or numbers are compared by ascertaining how many times one of the quantities contains, or is contained in, the other, that the relation of the one number or quantity to the other, is termed the *ratio*, and also that four numbers thus compared, in which the ratios of the two pairs of terms are equal, form a *proportion*.

We also stated that this principle of equal ratios is the basis of a great number of Euclid's geometrical propositions, as also of the relations existing between the sides and angles of triangles, as set forth in Trigonometry. Thus: when two sides of a triangle are proportional to the two sides of another triangle, each to each, and their included angles are equal, then the third side of the one bears the same proportion to the third side of the other, and the remaining angles of the one are equal to the remaining angles of the other, each to each; whence if two straight



lines of equal length, AE and BD , bisect each other at C , the point of intersection being equidistant from the extremities of each line respectively, then the distances AB and DE , between the opposite extreme points are proportionate to the lengths of the several lines from their extreme points to the point of intersection, that is to say

$$AC \text{ or } BC : DC \text{ or } EC :: AB \text{ or } y : DE \text{ or } x \dots \text{Eq. 1}$$

If the point C were exactly midway between A and E , then x and y would be equal, and if y were required to be twice as great as x , then AC would have to be equal to $2CE$, and so for any other ratio n , we have

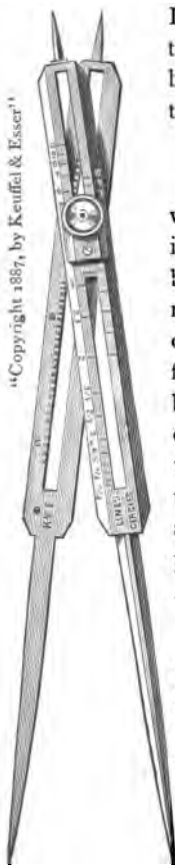
$$AC = n \times CE \dots \text{Eq. 2.}$$

The usefulness of the proportional Dividers, which we described in our September and October numbers, is derived from the proposition just stated, the two legs being represented by the lines AE and BD , and the movable pivot by their intersection at C . This pivot can be adjusted so that the ratio of x to y may vary from 1 to 1 up to 10 to 1, the setting of the pivot being facilitated by means of different scales engraved on the legs. The scale most generally used is that called the scale of LINES, which is graduated for ratios of 1 to $1\frac{1}{2}$ up to 1 to 10. The method of graduating is determined as follows:—Let the ratio of the distance between the points D and E to the distance between the points A and B , be designated by n , then we have

$$x : y :: 1 : n \dots \text{Eq. 3.}$$

Now as from Eq. 1, $x : y :: CE : AC$, it naturally follows that $CE : AC :: 1 : n$, and as the graduations serve to indicate the point of intersection C to which the pivot should be set, its position depends upon the value of n . The whole length of a leg $AE = AC + CE$, and as by Eq. 2, $AC = n \times CE$, then $AE = (n \times CE) + CE = (n + 1) CE$, and consequently the length of

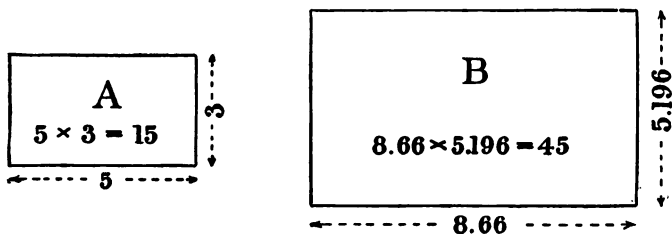
$$CE = \frac{AE}{n + 1} \dots \text{Eq. 4.}$$



Let us suppose that our Dividers are 9 inches long, and that we wish to set the pivot so that we may be able to enlarge a drawing in the proportion of 1 to 3, then we have $AE = 9$ inches and $r = 3$, consequently CE or $CD = \frac{9}{3+1} = 2.25$ inches, so that the centre of the pivot must be $2\frac{1}{4}$ inches from the points D and E . When the pivot is thus set, the opening AB will be always 3 times as great as the opening DE . This method of proceeding may be adopted when the ratio required is not found on the engraved scales of the Dividers, although we ourselves are of the opinion that it would be very useful to have in place of the scale of circles, which is comparatively little used, a scale of equal parts from point to point, say 250 parts in the 9 inches. Any ratio, such even as that of the diameter of a circle to its circumference could then be easily set off, seeing that in that case $n = 3.1416$, whence

$$CE = \frac{250}{3.14 + 1} = 60.4.$$

The area of a square is to the area of another square, as the square of the side of the one is to the square of the side of the other; so also the area of a plane figure is to the area of another similar plane figure, in proportion to the squares of the straight lines of which such plane figures are formed.



We have, therefore :

$$\left\{ \begin{array}{l} \text{Square of a Side} \\ \text{of any Figure } A \\ = x^2 \end{array} \right\} : \left\{ \begin{array}{l} \text{Square of a Side} \\ \text{of any Figure } B \\ = y^2 \end{array} \right\} :: \left\{ \begin{array}{l} \text{Area of} \\ \text{Fig. } A \end{array} \right\} : \left\{ \begin{array}{l} \text{Area of} \\ \text{Fig. } B \end{array} \right\}$$

Then if the ratio of the area of Fig. A be to the area of Fig. B as $1 : n$, we have

$$x^2 : y^2 :: 1 : n \dots \dots \dots \text{Eq. 5.}$$

whence we have the ratio of the *lines* composing these figures :

$$x : y :: 1 : \sqrt{n} \dots \dots \dots \text{Eq. 6.}$$

but

$$x : y :: CE : AC$$

therefore

$$CE : AC :: 1 : \sqrt{n},$$

and as $AE = AC + CE$

it follows that $CE : AC + CE :: 1 : \sqrt{n} + 1$

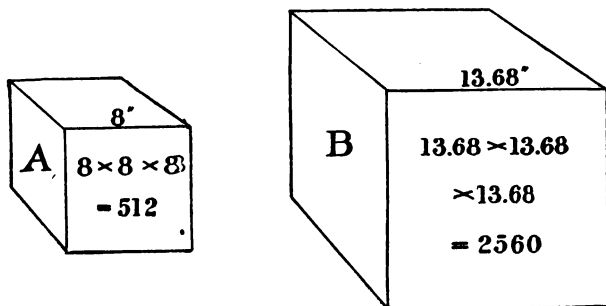
whence $CE = \frac{AE}{\sqrt{n} + 1} \dots\dots\dots \text{Eq. 7.}$

The scale of PLANES is used for reproducing a drawing in which the area of any given plane figure is required to bear in the copy a certain proportion to that of the original. Its graduations are obtained by means of Eq. 7; thus, suppose we wish to make a copy of Fig. *A*, but whose area shall be 3 times as great, that is $n = 3$, and let $AE = 9$ inches, we have

$$CE = \frac{9}{\sqrt{3} + 1} = 3.3.$$

If the centre of the pivot is set, therefore, at 3.3 inches from the points *D* and *E*, and the measurements of Fig. *A* be taken between the points *D* and *E*, and transferred to our paper by the points *A* and *B*, the area of *B* will be in the required proportion. Settings for any other desired ratio may be obtained in this manner.

The contents of any cube are to the contents of any other cube, as the cube of the side of the one is to the cube of the side of the other, and likewise the contents of any other regular solid figure are to the contents of any other similar solid figure, in proportion to the cubes of the straight lines forming such figures. Following, therefore, the same reasoning as



for areas, and supposing the ratio of the contents of Fig. *A* to the cubic contents of Fig. *B* to be as $1 : n$, we have

$$x^3 : y^3 :: 1 : n \dots\dots\dots \text{Eq. 8.}$$

whence, for the ratio of the *lines* composing the sides of the figures, we have

$$x : y :: 1 : \sqrt[3]{n} \dots\dots\dots \text{Eq. 9.}$$

The scale of SOLIDS is therefore used to reproduce any solid figure, whose contents are required to bear in the copy, a given proportion to

those of the original, and the setting of the pivot is obtained from Eq. 4 thus

$$CE = \frac{AE}{\sqrt[8]{n} + 1} \dots\dots\dots \text{Eq. 10.}$$

We may, therefore, by means of equations 4, 7 and 10, obtain settings of the pivot for any ratios which are not indicated by the graduations of the different scales.

The fourth scale found on the Proportional Dividers, the scale of CIRCLES, gives the ratio of the diameter of a circle to the side of an inscribed regular polygon, having any number of sides from 5 to 20. The length of a side of a regular polygon is equal to the sine of half the angle at the centre subtended by one side, multiplied by the diameter of the circumscribed circle, thus in a polygon of 8 sides, the angle at the centre is equal to $\frac{360^\circ}{8} = 45^\circ$, and the sine of $\frac{45^\circ}{2}$ or $22^\circ 30' = .3827$. If, therefore, the diameter of a circle be 1, then the side of an inscribed octagon will be .3827, and if we call this ratio n as before, we have

$$\text{Diam. Circle } x : \text{Side Polygon } y :: 1 : n$$

whence to obtain any setting of the pivot we have

$$CE = \frac{AE}{n + 1} \dots\dots\dots \text{Eq. 11.}$$

In some instruments the ratio given is that of the radius to the side of the inscribed polygon, instead of the diameter.

The Proportional Dividers may also be used for obtaining graphically the square root of a number, thus: Let n on the scale of Planes = the number whose square root is required, then by Eq. 6 we have $x : y :: 1 : \sqrt{n}$. We now make the opening $y = n$, according to any convenient scale of equal parts, and have consequently

$$x : n :: 1 : \sqrt{n}, \text{ from which}$$

$$x = \frac{n \times 1}{\sqrt{n}} = \sqrt{n} \dots\dots\dots \text{Eq. 12.}$$

To obtain, for example, the square root of 7, we set the pivot to 7 of the scale of Planes, then open out the Dividers and take from a suitable scale of equal parts, 7 such parts in the opening y . On applying the opening x to the same scale, we find it to be equal to 2.65 such parts. This is, therefore, the graphic square root of 7 to the given scale of equal parts.

We may also in like manner obtain the cube root of a given number by means of the scale of solids.

(To be continued.)

WEATHER PROGNOSTICS.

TO BE ABLE to foretell the state of the weather, if it could be done with absolute certainty, would be a great boon to the Engineer and Surveyor. Even with a reliable barometer, this is only possible to a limited degree, and requires no little amount of study and attention. The following prognostics, adopted some years ago by the Farmer's Club of the American Institute, and which are looked upon as the most reliable by competent judges, may be found useful.

OBSERVATIONS.	APPEARANCES.	PROGNOSTICS.
The wind always blows from a region of fair weather toward a region where a storm is forming.	When the temperature falls suddenly :	A storm is forming to the South.
Cirrus clouds (curl-cloud, cat's-tail) always move from a storm region to a region of fair weather.	When the temperature rises suddenly :	A storm is forming to the North.
Cumulus clouds (hay-cock) always move from a region where a storm is forming.	When cirrus clouds are moving rapidly from the North or Northeast :	There will be rain within 24 hours, no matter how cold it is.
The wind always blows in a circle around a storm.	When cirrus clouds are moving rapidly from the South or Southeast :	There will be a cold hailstorm on the morrow if it be in summer, and there will be a snowstorm if it be in winter.
	When the wind blows from the North :	The heaviest rain is to the East.
	When the wind blows from the South :	The heaviest rain is to the West.
	When the wind blows from the East :	The heaviest rain is to the South.
The wind never blows unless rain or snow is falling within 1000 miles.	Whenever heavy white frost occurs :	A storm is forming within 1000 miles to the North or Northwest.

The following couplet, used by our forefathers, possesses more truth than literary merit :—

A red sky at *night* is the shepherd's *delight*.

A red sky in the *morning* is the shepherd's *warning*.



"COPYRIGHT, 1891, BY WILLIAM COX, NEW YORK."

**A Monthly Journal for Engineers, Surveyors, Architects, Draughtsmen
and Students.**

Vol. I.

MARCH, 1, 1892.

No. 8.

*AN ASSORTMENT OF HANDY INSTRUMENTS FOR
THE DRAUGHTING ROOM.*

ONE IS SOMETIMES astonished to see what an amount of really good work can be done with a few tools by a ready man, able and accustomed to adapt himself to circumstances and to make use of expedients. The same applies also in a great measure to the capable draughtsman, who with but few instruments is able to produce accurate and well finished drawings. It will be very generally conceded that it is essential in such a case that those instruments should be good ones, well made, perfect in their proportions and as well finished as possible. It must not however be inferred that it is not often both wise and profitable to have at one's disposal more than a limited supply of instruments, to include special ones, designed for and suited to particular classes of work. We purpose describing a few such which will be found to answer in every respect the objects intended and to afford the draughtsman every satisfaction in their use.

It is often, especially perhaps in mechanical or architectural drawing,

necessary to draw very small circles. When such are produced with ordinary compasses, however small, the result is generally unsatisfactory.



Fig. 1.

To meet such a real want, the Spring Bow Pens with self-adjusting point, shown in figures 1 and 2, have been specially devised. The body of the instrument shown in Fig. 1 consists of a tube through which a fine steel rod passes freely, one end being tapered to a fine point whilst the other is provided with a milled head serving as handle. The pen is attached to the body by a spring and the opening or radius regulated by a small thumb screw. To use this Bow Pen, the centre point is held gently on the paper in a vertical position by the forefinger of the left hand resting lightly on the milled head, whilst the tube with the pen is turned round with the other hand, its own weight forming a sufficient contact with the paper to make a clear line, thus avoiding the slipping of the needle or the scratching of the pen. As the centre point does not revolve, it is quite unnecessary to deface the drawing with centre marks or holes. It will, however, be found quite

as easy with a little practice, to manipulate this pen with the right hand alone, holding the milled head with the forefinger, and turning the instrument round with the thumb and second finger.

The Spring Bow Pen Fig. 2 is very similar in principle to the other, the difference being that the frame or body of the instrument slides freely up or down on the steel rod, but is prevented from revolving around it by a small pin attached to the handle which passes through a slot in a tongue fixed to the upper part of the frame, so that one hand alone is required to use it. By means of a small set screw in the middle of the frame, this may be fixed to any part of the centre rod, making it practically an ordinary Bow Pen.

Fig. 1 is arranged to take either a pencil or pen point like ordinary compasses. These two Spring Bow Pens, whose quality and workmanship are of the finest, will be found to be the best instruments devised for drawing very small circles. The illustrations are $\frac{2}{3}$ ds of the natural size.

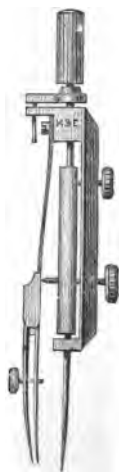


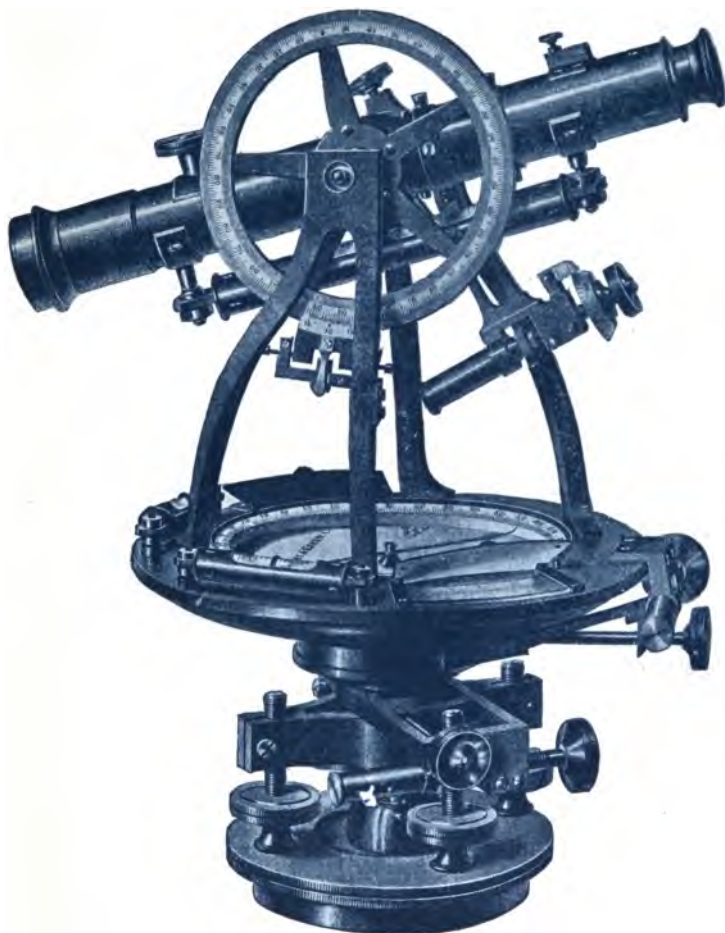
Fig. 2.

(To be continued)



*ENGINEERING AND SURVEYING INSTRUMENTS.**(Continued.)*

THE TRANSIT.



THE GRADIENTER ATTACHMENT is used, we have said, for fixing grades, measuring horizontal distances and differences of level, and—in directly—for computing angles. It will be seen from the accompanying figure, representing an Engineer's complete Transit, with this useful attachment, that it is a modification of the ordinary clamp and tangent screw, as applied to the telescope axis for enabling it to be elevated or depressed with great delicacy and precision. With the ordinary tangent screw the *angular* variation of the telescope is measured on the vertical

limb in terms of arc, whereas with the Gradienter, this variation is obtained in terms of the relation of the vertical to the horizontal distance.

The head of the tangent or micrometer screw is generally divided into 50 equal parts (sometimes however 100) and the pitch of the screw and the length of the clamp arm are so determined that one complete revolution of the micrometer head raises or lowers the line of sight or optical axis of the telescope 0.5 foot vertically in a horizontal distance of 100 feet, consequently each single division indicates an elevation or depression of 0.01 foot in the same distance. A small graduated index, attached to the arm, shows the number of complete revolutions of the screw, while the graduations of the micrometer head, as they pass under the index, show at once the fractional parts in fiftieths of a revolution.

The principles upon which the Gradienter is based, will be seen to be exceedingly simple. It must however be borne in mind, that absolute accuracy is only obtained within restricted limits, in fact to that extent in which the sines and tangents of angles may be said to coincide; for, as the screw impinges at right angles to the radial arm of the telescope upon a stud fixed to the standard, it is evident that the centre of contact cannot be always constant, but must be more and more removed from the axial centre of the telescope as the angle increases. As the pitch of the threads of the screw is uniform throughout, it naturally follows that each succeeding turn of the micrometer head will elevate or depress the telescope by a diminishing quantity, and that in proportion as the length from the axial centre of the telescope to the centre of contact of the screw increases. For angles up to 3° the error can however be scarcely appreciated, but above this it increases more rapidly.

It is true that the use of the Gradienter is almost wholly confined to these limits, as an elevation of the telescope through an arc of 3° is equivalent to a rise of 5.234 per 100, which is beyond the limits of general practice. In the case of distances, to the measuring of which the Gradienter is, as already stated, applicable, angles exceeding 3° can be but rarely used, as such an angle is equivalent to more than 15 feet measured on a vertical rod only 300 feet distant. If therefore distances of 1000 feet were being measured, an elevation of 1° would necessitate the use of a rod at least $17\frac{1}{2}$ feet high, so that any greater angle is clearly out of the question. Under these circumstances it seems to us that we may assume the accuracy of the work done by means of this very useful and valuable attachment.

We shall now examine the methods of using the Gradienter, and that firstly for the measuring of distances and fixing of grades on *level ground*.

Example 1.—To ESTABLISH A GRADE OF $2\frac{1}{2}$ PER CENT, OR 2.5 FEET VERTICAL TO 100 FEET HORIZONTAL.

Set the Transit over the station and level it, then bring the telescope

level by means of the clamp and gradienter screw. Note the reading of the index and the micrometer head, say $2\frac{37}{50} = 137$ divisions; to this add 250 divisions, making 387 or $7\frac{37}{50}$, so that the screw must be turned round until the index marks 7, then continue turning until the micrometer shows 37 against the index. All points in the line of sight of the telescope will then form with the horizontal line passing through the telescope axis, a rise of $2\frac{1}{2}$ feet in a hundred, or in the ratio of $2\frac{1}{2}$ feet vertical to 100 feet horizontal.

Example 2.—TO ASCERTAIN THE GRADE BETWEEN A GIVEN STATION AND A GIVEN POINT.

Set the Transit over the station, level it and the telescope, then note the readings of the index and micrometer head, say $1\frac{34}{50} = 84$ divisions. Hold a leveling rod vertically or plumb upon the given point, with the target set at the height whose grade is required. After directing the optical axis of the telescope upon the target, note again the readings of the index and micrometer head, say $8\frac{26}{50} = 426$ divisions. The difference of these two readings or $426 - 84 = 342$ (that is 6 revolutions of the screw and 42 divisions of the micrometer head) is the grade, that is a rise of 3.42 feet in 100 feet.

It should be noted that the graduations on the index are generally for the sake of convenience so made that each one denotes 2 complete revolutions of the micrometer head, or 100 divisions, equal to an elevation or depression of 1 per cent. In practice therefore, the readings are at once made in feet taken from the index, and in hundredths taken from the micrometer head, it being easily seen by the position of the latter in relation to the index, whether they are more or less than 50. In this way Example 1 would be read:

$$1.37 + 2.50 = 3.87,$$

and Example 2:

$$4.26 - 0.84 = 3.42.$$

We shall in further examples follow this method as, being decimal, it is simpler and is also very easily understood.

Example 3.—TO MEASURE THE DISTANCE BETWEEN TWO POINTS.

Set the Transit over one of the points, level the plates and the telescope as in the previous examples. Hold a rod vertically over the other

point, and after directing the telescope to it note the reading on the rod, say 4.35 feet. Turn the micrometer head now two complete revolutions and note again the reading of the rod, say 9.46 feet. The difference of these two readings, or $9.46 - 4.35 = 5.11$ multiplied by 100, gives the distance from the station of observation to the point observed, that is 511 feet. It may sometimes be found convenient to turn the micrometer head round 4, 6, 8 or 10 times, in which case the product of the difference of the rod readings multiplied by 100 must then be divided by 2, 3, 4 or 5, in order to obtain the distance.

Measurements of distance may also be obtained by means of any rod or pole having upon it two targets or marks, whose distance apart is either known or may be ascertained. A wall or building with two chalk or other marks upon it, one above the other, will do equally well. In such case bring the telescope on one mark and note the readings of the index and micrometer head, then direct the telescope upon the other mark by means of the gradienter screw and note again the readings of the index and micrometer head. This gives us the following proportion :

$$\text{Distance} : 100 :: \left\{ \begin{array}{l} \text{Distance} \\ \text{between targets} \\ \text{in feet.} \end{array} \right\} : \left\{ \begin{array}{l} \text{Difference of} \\ \text{Readings of} \\ \text{Gradienter.} \end{array} \right\}$$

whence

$$\text{Distance} = \frac{\text{Distance between targets in feet} \times 100.}{\text{Difference of Readings of Gradienter.}}$$

Let, for instance the distance between two targets on a rod, or between two marks on a wall, be 5 feet, and the readings of the Gradienter be 3.75 and 6.21, then we have

$$\text{Distance} = \frac{5.00 \times 100}{6.21 - 3.75} = \frac{500}{2.46} = 203.25 \text{ feet}$$

as the distance from the wall to the telescope axis.

The great advantage of this method of measuring distances lies in the fact of our being able to use fixed and distinct marks on the rod, such as targets whose intervening distance is known or can be afterwards measured, instead of having to read the fine divisions of a leveling rod, which at a moderate distance are apt to be productive of errors.

In our next article we shall examine the methods of using the Gradienter on sloping ground.

(To be continued.)

BOOKS RECEIVED.

HOW TO BECOME AN ENGINEER is a subject which has of late received considerable attention in many of the leading journals devoted to such subjects. It is also the title of the 100th issue of the Van Nostrand Science Series, and is well worthy of perusal by all those whose ambition directs them in this line. It contains a summary of the best thoughts and opinions of eminent authorities, as well as an outline of the various suitable courses of instruction in this and European countries.

THE COLLIERY MANAGER'S POCKET BOOK and Diary for 1892. This is the 23d year of publication of this handy book, which, although specially prepared for English Managers, yet contains much information which will be found useful on this side of the ocean, apart from its convenience as a diary. Amongst other articles may be mentioned interesting ones on "Electricity for Mining Purposes" and "Ventilation," by acknowledged authorities. From the various data given we have worked out the following Gauge Points for ascertaining the weight of Coal under an acre of land, for varying thicknesses of seams and different specific gravities, which will be useful for Slide Rule or arithmetical computations, and may interest some of our readers, thus

$$\frac{14}{17} = \frac{\text{Thickness of seam in inches.}}{\left\{ \begin{array}{l} \text{Weight of Coal under an acre} \\ \text{of land in hundreds of Tons.} \end{array} \right.}$$

For different Specific Gravities use the following Gauge Points:

Specific Grav.	1.20	1.25	1.30	1.35	1.40	1.45	1.50
Exact Ratio, 1 to	1.2154	1.2660	1.3167	1.3673	1.418	1.4686	1.5192
Gauge {	14	15	19	30	55	47	25
Points. {	17	19	25	41	78	69	38

THE WEIR FROG COMPANY, Cincinnati, Ohio, have just issued a new catalogue, which is in fact much more than what its name indicates. From it much useful information respecting frogs, switches and crossings may be obtained with rules for laying out turnouts etc. The illustrations present some 75 different devices, some of which will be found to be quite new. The book is handsomely got up and well printed, while the illustrations are carefully and clearly executed. Any one interested can obtain a copy upon application.

THE MECHANICAL WORLD POCKET DIARY for 1892 is another small book, convenient for the pocket, containing a collection of useful notes, formulas, recipes and tables, arranged for the use of Engineers, Draughtsmen, Mechanics and others. It is got up by Charles N. Pickwith, Editor of the *Mechanical World*, Manchester, England, a paper well known in this country.

THE COMPASS.

A Monthly Journal published the first of every month, at 127 Fulton Street, New York City.

WILLIAM COX, - - - - -	Editor.
KEUFFEL & ESSER CO., - - - - -	Publishers.

SUBSCRIPTION \$2.00 per year, in advance, postage paid. Single Copies, 20 Cents each.
CORRESPONDENCE should be addressed to the Editor of *THE COMPASS*, 127 Fulton Street, New York City.

All such bearing upon the topics to which the Journal is devoted, will be thankfully received and acknowledged with pleasure.

CONTENTS.

	PAGE.
An Assortment of Handy Instruments for the Draughting Room, - - -	113
Engineering and Surveying Instruments, - - - - -	115
Books received, - - - - -	119
To our Readers, - - - - -	120
The Metric System, - - - - -	121
The Accuracy of Slide-Rule Computations, - - - - -	124
Thompson's Improved Leveling Target, - - - - -	125
Scientific Progress in 1891, - - - - -	126
The Decimal Division of the Circle, - - - - -	128

TO OUR READERS.

IN REPLY TO numerous inquiries, the *UNIVERSAL ADDING MACHINE* and *WEBB'S ADDER*, described in our last issue, may be had of Keuffel & Esser Co., the publishers of *THE COMPASS*. The prices are:

Universal Adding Machine.....\$8.00.
 Webb's Adder.....\$7.00

A. M. S. WRITES US:—Your article on Perspective Drawing in the February "*Compass*" suggests that I would very much like to have you devote a little space to the reason why objects at a distance appear smaller than when nearer.

It seems to us that any attempt to show *why* perspective exists would be as useful as to try to explain *why* the needle always veers round to the North, or why electricity etc. exist. Such occurrences are well known facts, and their discussion would lead us beyond the scope of our journal, which aims to be practical. Any elementary work on optics will supply all the information needed.

THE METRIC SYSTEM.

ATTENTION HAS BEEN of late again directed through different mediums to the advantages of the Metric system. Without advocating its adoption in all cases and under all circumstances, we believe that if its use were made obligatory in this country, the change would be hailed with satisfaction by the engineering profession in general. We take our stand therefore upon the premise laid down in the report of Prof. T. C. Mendenhall, of September 16, 1889, to the Secretary of State at Washington, namely: "That a uniform system of weights and measures would greatly facilitate international intercourse, not only in a commercial but in a no less important intellectual sense, is so universally admitted that the question may be said to have passed the stage of argument." Further on in his report Prof. Mendenhall says, "In all the important conferences, and especially in the statistical and monetary, in which the subject of weights and measures received attention (and it is a subject of almost universal concern) the weight of opinion has been in favor of a decimal international system; the metric system combines the decimal with a simple correlation between the units of length, weight and capacity, and being the only existing system possessing these advantages, it has been chosen, more because of its inherent merits than by preconcerted action, as the one best adapted to meet international wants of a certain kind, and it is also being rapidly recognized as the most suitable medium for conducting commercial transactions."

In view of the increasing favor with which this system is being regarded, it seems to us that a fuller acquaintance with its principal features and more practice in its use would be great advantages, especially in a country like our own, so largely engaged in commercial relations with the sister republics of this continent, and so frequently called upon to assist in engineering undertakings in those countries.

The object of this article is therefore rather to lay before our readers some simple methods of reducing quantities or values of the one system into equivalent ones of the other system. Such reductions are usually made by taking *unity* of one system and multiplying it by its equivalent of the other, but it often happens that to obtain an accurate result, we are compelled to make use of a factor of several figures, as we showed, page 73, in the case of the diameter and circumference of a circle. We propose, therefore, to give a list of EXACT RATIOS with their corresponding GAUGE POINTS or EQUIVALENTS, whose departure from the exact ratio will in no case attain 1 per mille. By giving the exact ratios with the Gauge Points, either method of solution may be adopted according to individual preferences, while the Gauge Points allow of reductions being made from the ordinary system into the metric and *vice versa*. These

equivalents will also be found very useful for Slide Rule practice, being very easy to "set," as they all fall on marked divisions of the scales, thus dispensing with the necessity of estimating subdivisions. Some of these ratios and equivalents, applicable to combinations of terms are original, and will be found to simplify considerably a certain class of calculations.

Example :—What is the equivalent in Kilogrammes per square metre of a pressure of 46 pounds per square foot ?

Here the Gauge Points are

34 pounds per sq. foot = 166 Kilog's per sq. metre, so that we have

$$\frac{46 \times 166}{34} = 224^{\frac{1}{2}} 5882$$

and with the Slide Rule

$$\begin{array}{l} C \parallel \text{Set } 34 \mid \text{Under } 46 \text{ pounds} \\ D \parallel \text{To } 166 \mid \text{Find } 224^{\frac{1}{2}} 6 \end{array}$$

The exact ratio is 1 pound per sq. foot = 4.8826 Kilog's per sq. metre, from which we have

$$46 \times 4.8826 = 224^{\frac{1}{2}} 5996,$$

which shows that the result obtained by means of equivalents is sufficiently accurate for all practical purposes.

WEIGHTS AND MEASURES.

Exact Ratios. Gauge Points and Equivalents.

1 = 1.5875	160 = Sixteenths of an inch
	254 = Millimetres
1 = 2.5399	26 = Inches
	66 = Centimetres
1 = 0.30479	210 = Feet
	64 = Metres
1 = 0.91438	70 = Yards
	64 = Metres
1 = 1.6093	87 = Miles
	140 = Kilometres
1 = 0.20116	860 = Links
	173 = Metres
1 = 20.116	43 = Chains
	865 = Metres
1 = 1.8539	41 = Knots
	76 = Kilometres

$1 = 6.4514$	$\frac{31}{200} =$ Square inches Square centimetres
$1 = 0.0929$	$\frac{140}{13} =$ Square feet Square metres
$1 = 0.8361$	$\frac{61}{51} =$ Square yards Square metres
$1 = 0.40467$	$\frac{42}{17} =$ Acres Hectares
$1 = 2.5899$	$\frac{73}{189} =$ Square miles Square kilometres
$1 = 16.3862$	$\frac{5}{82} =$ Cubic inches Cubic centimetres
$1 = 0.0283$	$\frac{600}{17} =$ Cubic feet Cubic metres
$1 = 0.7645$	$\frac{17}{13} =$ Cubic yards Cubic metres
$1 = 28.315$	$\frac{6}{170} =$ Cubic feet Litres
$1 = 3.785$	$\frac{14}{53} =$ U. S. Gallons Litres
$1 = 4.5435$	$\frac{46}{209} =$ Impl. Gallons Litres
$1 = 0.0648$	$\frac{540}{35} =$ Grains Troy Grammes
$1 = 28.349$	$\frac{6}{170} =$ Ounces Ave Grammes
$1 = 0.45359$	$\frac{280}{127} =$ Pounds Kilogrammes
$1 = 50.802$	$\frac{5}{254} =$ Hundredweights Kilogrammes
$1 = 1.016$	$\frac{250}{254} =$ Tons Metric tonnes

NOTE.—When computations are being made with the Slide Rule, and the required equivalent lies beyond the end of the rule, bring the runner to the right or left index of the slide (as the case may be) then push the slide so that the other index shall coincide with the runner, when the required equivalent will be at once found.

(To be continued.)

THE ACCURACY OF SLIDE-RULE COMPUTATIONS.

Inst. C. E. : Foreign Abstracts.

IT IS WELL KNOWN that for simple multiplications, or for multiplications with three factors, the ordinary slide-rule, 25 centimetres in length, gives an approximation of 0.1 to 0.2 per cent. of the result. On testing a number of celluloid slide-rules of German make, the author found the mean error in simple multiplication to be $\frac{1}{800}$. This result was obtained with rapid reading; with very careful setting and reading, the error may be brought to 0.1 per cent. or possibly less. Besides this pocket slide-rule, which is indispensable to every engineer, it is desirable for many kinds of calculations to have in the office a slide-rule, not necessarily so portable, but giving more accurate results. In Germany, for this purpose, there are employed:

- 1st. The 50 centimetres slide-rule;
- 2nd. Other slide-rules of various dimensions, such as that of Landsberg, 723 millimetres in length; and
- 3rd. Beyerlen's calculating circle with a diameter of 120 millimetres, representing a slide-rule 754 millimetres in length.

With the first of these, an accuracy of 0.08 per cent. can easily be obtained with rapid reading, and with the 120 millimetre calculating circle, the accuracy obtainable is 0.07 to 0.05 per cent. In England and America, of late years, two improved forms of slide-rule have come into use, the Fuller rule and the Thacher rule. Careful tests made by the author with the Fuller rule in the collection of the Stuttgart Technical School, gave a mean error of 0.008 per cent., or approximately $\pm \frac{1}{12500}$, showing that the accuracy of $\frac{1}{10000}$ claimed for this rule by the makers is not exaggerated. As a further test, the author calculated the area of a hexagon, of which the co-ordinates of the corners were given. The following were the results obtained:—

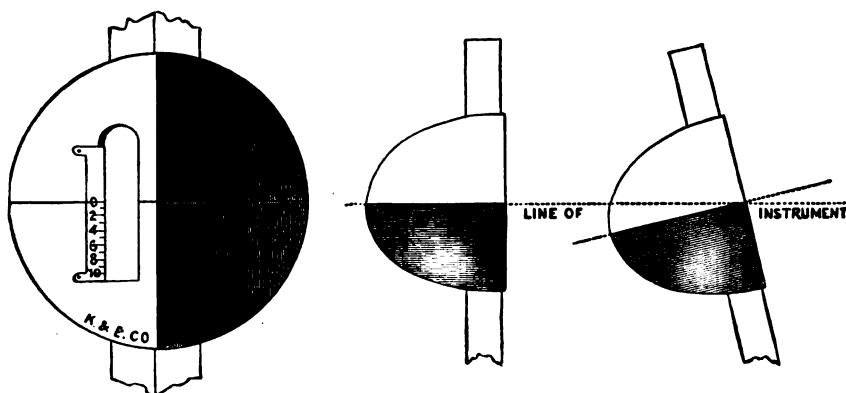
Method employed.	Area in square metres.	Time occupied in Mins.
1. Direct calculation.....	6663.61	9
2. Calculation with five-figure logarithms.....	6663.57	9
3. Calculation with the Fuller rule.....	6663.6	7½
4. Calculation with the 50 centimetre rule.....	6665.5	5
5. With the calculating machine.....	6663.61	10
6. With Zimmermann's multiplication tables.....	6663.61	7½

It should be pointed out that the result obtained with the greatest rapidity (No. 4) is hardly sufficiently accurate; whilst in the slowest method No. 5) the mental effort is least.

More accurate results are obtained with the Thacher rule than with the Fuller rule. Tests made by the author with the Thacher rule in the collection of the Stuttgart Technical School gave a mean error of 0.0031 per cent., or approximately $\pm \frac{1}{32000}$. In this case the settings and readings were made with care. With rapid reading the approximation of $\frac{1}{2000}$ can easily be obtained.—*The Mechanical World*.



THOMPSON'S IMPROVED LEVELING TARGET.

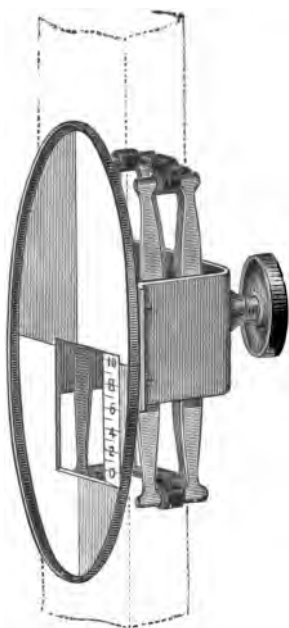


PATENTED JUNE 11, 1889.

Fig. 1.

TWO METHODS OF HOLDING the rod when taking stadia or gradienter measurements are in vogue, and each one has its advocates. Some have adopted and recommend that it be always held at right angles to the line of sight of the telescope, while others as strongly favor its being held plumb or vertical. It is not in our province to decide which method presents the greatest advantages. Our object is to present to the advocates of the former system a Patent Leveling Target, which will, we are sure, commend itself to them by reason of the evident advantages it possesses for the class of work referred to.

The horizontal dividing line on the target is carried over two surfaces placed at right angles to each other, so that it only shows as a continuous and unbroken line when the rod is held perpendicular to the line of sight. The position of the rod is thus always under the control of the observer, besides an efficient check upon a careless rodman being furnished.



Patented March 16, 1886.

Fig 2.

This target also presents a greater bearing surface to the rod and is steadier than the ordinary form, and when combined with Keuffel & Esser Co.'s patent Rollers, Fig. 2, is the easiest to set, the most convenient to move and the most positive in its action, as the rollers, with which the binding springs are provided, bear against the rod, and enable the target to be moved up or down easily and without any jerking. Another important point is that the rollers do not wear the rod, but prevent the scraping inevitably resulting from the contact of springs, to the great detriment of the divisions on the rod.

It is needless to add that this Target will also be found exceedingly useful for leveling and other work requiring the rod to be held perfectly plumb.

SCIENTIFIC PROGRESS IN 1891.

THE MOST IMPORTANT contribution to theoretical astronomy during the year 1891 was the exhaustive paper of Professor Harkness on the Solar Parallax and its related Constants. He has collected the most trustworthy astronomical, physical and geodetic constants which are intimately connected with the solar parallax, and by a judicious adjustment of them, using the principle of "Least Squares" for that purpose, has deduced a homogenous system of values which harmonize well with the results of observation. A summary of his results is as follows:

- Equatorial semi-diameter of the earth, 20,925,293 feet;
- Polar semi-diameter, 20,855,590 feet;
- Mean density of earth (water being 1), equals 5.576;
- Length of the seconds pendulum at equator, 39.01254 inches

Acceleration of terrestrial gravity at equator per second of mean solar time, 32.086528 feet ;

Length of sidereal year, 365 days, 6 hours, 9 minutes, 9.314 seconds (mean time) ;

Length of tropical year, 365 days, 5 hours, 48 minutes, 46.069 seconds (mean time) ;

Solar Parallax, $8.80905'' \pm 0.00567''$;

Mean distance of earth from sun, 92,796,950 miles, with a probable error of not more than 60,000 miles either way ;

Mean distance of moon from earth, 238,854.75 miles, with a probable error of only 9,916 miles ;

Velocity of light, 186,337 miles per second.

The method of determining celestial motions in the line of sight, by means of the spectroscope, is yielding extraordinary but not altogether unforeseen results, and is furnishing us with a separating power which far surpasses that of any telescope. The spectroscope has added greatly to our list of binary stars, and has given us for the first time a knowledge of a new class of stellar systems in which the components are nearly equal in magnitude and in close proximity to each other. The star β Aurigæ has lately been found to be such a star. It consists of two suns, which revolve about their common centre of gravity in *four days*, at a distance from each other of between seven or eight millions of miles ; and assuming them to be of equal weight, each is a little more than double the weight of our sun. This extraordinary condition of things is probably not a permanent one, but one of the stages in the evolution of the life history of the system. This unique arrangement of suns is probably due to two centres of condensation, instead of one in the nebula, out of which this system was originally evolved. No telescope could ever reveal to us binary stars of this order. In the case of this close double star, an object glass of not less than *eighty feet* in diameter would be required to separate its components.

An arc of nearly 40° on the 52d parallel of north latitude has been lately measured geodetically in Europe, and the result is that this parallel is not a circle but an approximately circular curve, from which it follows that the earth is not an ellipsoid of revolution. A similar result was found in the case of the 42d parallel in the United States.—*The World Almanac*.



THE DECIMAL DIVISION OF THE CIRCLE.

VARIOUS METHODS have been made use of to distinguish centesimal degrees or grades from sexagesimal degrees, minutes and seconds, but so far no one standard has been generally adopted.

To designate, for instance, 24 degrees, 86 minutes and 50 seconds on the centesimal basis, we have, according to *Industries*, the following five different methods:

1. Hobert & Ideler, (Berlin, 1799)..... 0.24865
2. Borda's Tables, (Paris, 1801)..... 24° 86' 50"
3. Gravelius, (Berlin, 1886)..... 24° 86—50 =
4. New 8-figure Tables (Paris, 1891).... 24° 86' 50"
5. Prof. Jordan proposes..... 24^s 86° 50^{cc}

As the centesimal basis is being more generally employed for surveying instruments on the Continent of Europe and in other countries which have adopted the metric system, it is desirable that some uniform method be adopted. At a recent meeting of the Surveyor's Institute at Hanover, the question was brought under discussion when it was found that the fifth method, 24^s 86° 50^{cc} met with the most support. A few other proposals were made but were not considered worthy of adoption. No definite decision being yet arrived at, the subject is still open for discussion.

The following table will be found convenient for reductions from one system to the other; the centesimal degrees, etc., are indicated according to the proposed method of Prof. Jordan:

400 ^s	=	40,000°	=	4,000,000 ^{cc}	=	360°	=	21,600'	=	1,296,000"
100 ^s	=	10,000°	=	1,000,000 ^{cc}	=	90°	=	5,400'	=	324,000"
1 ^s	=	100°	=	10,000 ^{cc}	=	54'	=			3,240"
		1°	=	100 ^{cc}	=		=			32".4
				1 ^{cc}	=		=			0".324
360°	=	400 ^s								
90°	=	100 ^s								
1°	=	1 ^s 11° 11 ^{cc}								
1'	=	0 ^s 01° 85 ^{cc} 18								
1''	=	0 ^s 00° 03 ^{cc} 086								

WE REGRET that we are unable to continue in the present number the articles on *Series of Numbers* and *Speedy Calculators*; they will be resumed in our next issue.



"COPYRIGHT, 1891, BY WILLIAM COX, NEW YORK."

**A Monthly Journal for Engineers, Surveyors, Architects, Draughtsmen
and Students.**

Vol. I.

APRIL, 1, 1892.

No. 9.

*SERIES OF NUMBERS WITH EXAMPLES OF THEIR
PRACTICAL APPLICATION TO SCIENTIFIC
PURPOSES.*

(Continued.)



Fig. 1.

WE HAVE SHOWN how in a series of numbers in Geometrical Progression, any four consecutive terms may form a proportion, as

$$1 : 2 :: 4 : 8 \text{ or } 1 : 3 :: 9 : 27$$

These proportions may be varied infinitely and continued to any extent, provided that the relationship or correspondence of the terms of the first ratio be equally observed in the terms of the second ratio, this relationship being that of either the series in Arithmetical Progression or the series in Geometrical Progression. We may also take three consecutive or alternate terms of a Geometrical series

and make of them a proportion, provided that their positions in the series be similar, thus

$$2 : 4 :: 4 : 8 \text{ or } 4 : 16 :: 16 : 64$$

in which case the middle term of the series becomes the second term of the first ratio as well as the first term of the second ratio; this middle term is consequently the Geometrical Mean between the two extreme terms, thus

$$4 = \sqrt{2 \times 8}, \text{ and } 16 = \sqrt{4 \times 64}$$

We have also shown that numbers may be represented by distances, composed of a certain number of spaces, each space representing a given unit. We can therefore represent numbers graphically by lines, each one composed of a given number of space units, in accordance with the scale adopted.

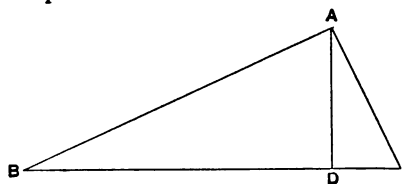


Fig. 2.

These theorems are exemplified in the case of a right angled triangle, when a perpendicular is drawn from the right angle to the hypotenuse, as shown in Fig. 2, where AD is perpendicular to BC . We have here three similar triangles, giving

us the following simple proportions :

$$DC : AD :: AD : BD :: AC : AB$$

$$DC : AC :: AC : BC :: AD : AB$$

$$BD : AB :: AB : BC :: AD : AC$$

whence we have

$$AD = \text{G. Mean between } BD \text{ and } DC \text{ or } AD = \sqrt{BD \times DC}$$

$$AC = \text{“ “ “ } BC \text{ “ } DC \text{ “ } AC = \sqrt{BC \times DC}$$

$$\text{and } AB = \text{“ “ “ } BC \text{ “ } BD \text{ “ } AB = \sqrt{BC \times BD}$$

A practical example of the application of these theorems is to be found in the Logarithmic Spiral Curve, Fig. 1, while the principles underlying its construction are those of a series of numbers in Arithmetical Progression, taken in conjunction with another series of numbers in Geometrical Progression, these two series being represented by lines of different lengths, varying in the one case by a given uniform rate of *difference*, and in the other by a given constant *ratio*. The following is the method of construction of this useful curve.

On the straight line XZ , Fig. 3, with centre P , and any radius PA ,

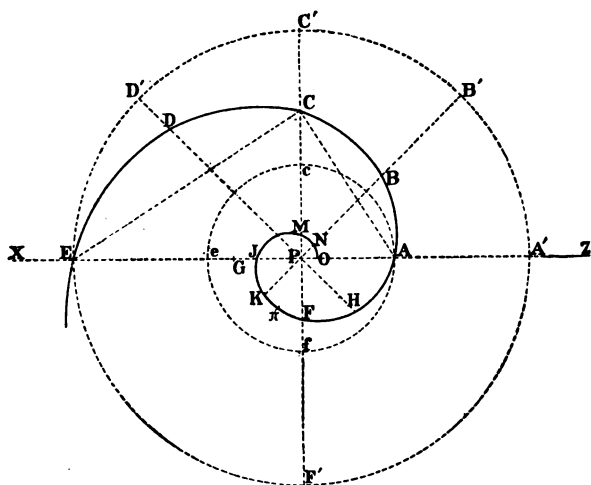


Fig. 3

draw the circle $A^1 c e f$; and with the same centre P , and any other greater radius PE , draw the circle $A^1 C^1 E F^1$. We have thus two radii PA and PE , between which a certain ratio is established. On these two radii we then proceed to construct our logarithmic curve, commencing at A and ending at E ; that

is to say, a curve must be traced with centre P , whose first radiant PA shall be the radius of the small circle $A^1 c e f$, and whose other radiants shall continually increase, and that uniformly in the *same ratio*, and in such measure, that the last one PE shall be the radius of the larger circle $A^1 C^1 E F^1$.* The various radiants of this curve $AB C D E$ will then represent the series of numbers in Geometrical Progression, whilst the arc $A^1 C^1 E$, equally divided in as many points as we have radii, represents the series of numbers in arithmetical Progression; consequently the different radiants must be capable of the same functions which we have shown appertain to a series of numbers in G. P. If, for instance, we divide the semi-circle $A^1 C^1 E$ into 10 equal parts, and draw radii to the centre P , these will indicate on the arc the different terms of a series of numbers in A. P., and the logarithmic curve must so cut them, that the length of the different radiants from the centre P to the curve, will indicate the successive terms of a series of numbers in G. P. The lengths of these radiants must be so proportioned, that the *same ratio* shall exist throughout between *any two* consecutive radiants.

Let us begin by dividing the arc $A^1 C^1 E$ into two equal parts, by drawing a radius from C^1 to the centre P perpendicular to $A^1 E$, so that the angles $A^1 P C^1$ and $C^1 P E$ shall be equal to each other; then the logarithmic curve must cut this radius in such a point C that there may be the same ratio between PA and PC , that there is between PC and

*We use the term radiant when applied to the logarithmic curve which we are tracing, as these are not the true *radii of curvature* of the spiral, which do not possess a common centre, as will be seen further on.

PE , that is to say, PC will be a mean proportional between PA and PE , thus :

$$PA : PC :: PC : PE$$

whence

$$PA \times PE = PC \times PC = PC^2$$

and

$$PC = \sqrt{PA \times PE}$$

Similarly, if we bisect the angle $A^1 PC^1$, and draw the radius $P B^1$, the logarithmic curve must also cut this radius in such a point B that

$$PA : PB :: PB : PC$$

and

$$PA \times PC = PB^2$$

so also by bisecting the angle $C^1 PE$ in D^1 , we obtain

$$PC : PD :: PD : PE$$

and

$$PC \times PE = PD^2$$

We have thus five lines of *increasing* length, PA , PB , PC , PD and PE , representing 5 terms of a series of numbers in Geometrical Progression, whose logarithms are represented by A^1 , $A^1 B^1$, $A^1 C^1$, $A^1 D^1$ and $A^1 E^1$, which are the terms of a series of numbers in Arithmetical Progression ; and in accordance with the laws which govern numbers in G. P., we have

$$\begin{array}{lll} PA : PB :: PC : PD & \text{whence} & PA \times PD = PB \times PC \\ PB : PC :: PD : PE & \text{"} & PB \times PE = PC \times PD \\ PA : PC :: PC : PE & \text{"} & PA \times PE = PC^2 \\ PA : PB :: PB : PC & \text{"} & PA \times PC = PB^2 \\ PA : PD :: PB : PE & \text{"} & PA \times PE = PD \times PB \\ \text{etc.} & & \text{etc.} \end{array}$$

It therefore follows that *if an angle, however large or small, formed by any two radiants be bisected, then the central radiant is a mean proportional between the outer radiants, or the square of the central radiant is equal to the product of the two extremes.*

We may now in the same manner continue this curve backwards from A through H , F and K to J , and further through M and N to O , always taking care that the same ratio exists between any two radiants enclosing equal angles. The curve might also be continued onwards in the same way from E , thus making a spiral of indefinite length. We thus obtain an endless number of similar ratios, out of which we can form an infinite number of proportions, as for example :

$$\begin{array}{l} PO : PN :: PA : PB \text{ or } PO : PA :: PN : PB \\ PO : PJ :: PH : PD \text{ or } PO : PK :: PB : PE \end{array}$$

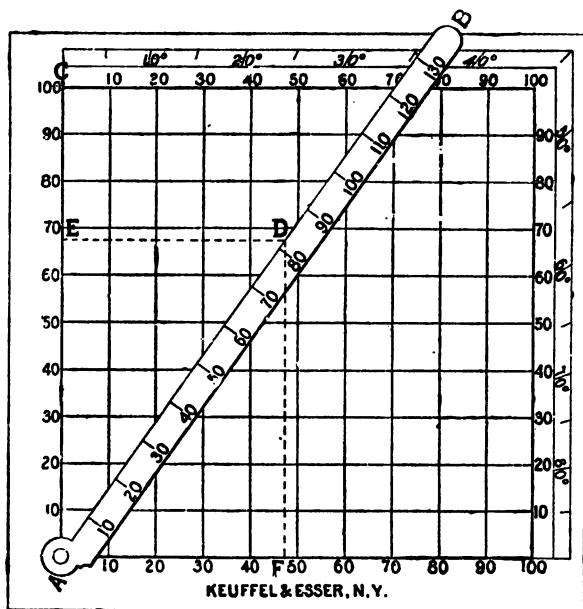
in which the two radiants or terms of each ratio of a proportion enclose equal angles.

(To be continued.)

SPEEDY CALCULATORS.

(Continued.)

THE TRIGONOMETER.



A DEVICE WHICH is exceedingly useful and which very much facilitates the surveyor's operations, is the TRIGONOMETER, illustrated herewith. This instrument is specially designed for the purpose of computing *Latitudes* and *Departures*, although it will be at once seen that a great variety of other Trigonometrical calculations may be very readily solved with it, and that with sufficient accuracy, not only to serve as a valuable check, but to take the place, in all ordinary field work, of tables or other modes of calculation.

The Trigonometer, also called a Co-ordinate Protractor, consists of a metal plate 15 inches square, divided both ways into 100 equal parts, each one of which is again subdivided into two equal parts. On the outside of the top and right-hand scales of equal parts is another scale of degrees, proceeding from 0° at *C* to 90° at the bottom of the right hand side, each one of which is also subdivided into quarters of 15 minutes each. An arm *A B*, divided like the plate, is fastened at *A*, and movable around that point, so that it can be set by means of the outer scale of degrees to include, with the left vertical scale *A C*, any angle as shown.

In order to calculate latitude and departure, let, in our illustration,

Angle $BAC = 35\frac{1}{4}^\circ = \text{Course}$
 and $AD = 83\frac{1}{4} \text{ feet} = \text{Distance},$
 then $DE = 48.7 \text{ feet} = \text{Departure},$

taken from the scale on the top of the plate, and

$DF = AE = 67.8 \text{ feet} = \text{Latitude},$

seeing that if AD is taken as the radius of the right-angled triangle ADE , then DE is the sine of the angle BAC and AE is the cosine of the same angle.

It is well known that in all ordinary surveys, latitude and departure of the various courses should be calculated in order to know whether a survey closes or not. The notes of such surveys are usually kept in the following manner:—

STA.	COURSE.	DIST.	NORTH	SOUTH	EAST.	WEST.
0	S. 57° W.	857		467		719
1	S. 72° E.	642		198	611	
2	N. $48\frac{1}{4}^\circ$ E.	964	639		722	
3	N. $53\frac{1}{4}^\circ$ W.	437	262			350
			901	665	1333	1069
			665		1069	
		Diff.	236		264	
5	Therefore closing course, S. $48\frac{1}{4}^\circ$ W.	354		236		264
			901	901	1333	1333

In this example, the latitudes and departures have all been calculated with the Trigonometer. After adding the columns of Northing, Southing, Easting and Westing respectively, the differences between the North and South, and the East and West courses, are the co-ordinates of the closing course of the survey. This can also be easily determined by the Trigonometer, by marking with a pencil the point of intersection of the latitude and departure, then placing the movable arm against this point, and reading off the course and the distance, thus

Excess of Northing..... 236 feet.
 “ “ Easting..... 264 “

whence the closing course should be S. $48\frac{1}{4}^\circ$ W., 354 feet.

The Trigonometer may also be used for obtaining the tangent and

secant of any angle, thus in the illustration let AC be the radius = 1.00, and we naturally have for the angle BAC ,

Tangent $35\frac{1}{2}^\circ = 0.713$ on the top scale from C to the arm, and

Secant $35\frac{1}{2}^\circ = 1.228$ on the arm from A to the top scale.

Similarly, if BAC is the angle of deflection of a curve, and AE is the radius, then having placed the arm to the given angle, DE is the tangent of the same. Inversely, if the tangent and the angle are known, the radius is at once found.

For PLOTTING there is no method more satisfactory than by means of co-ordinates, and these may be readily obtained with the Trigonometer with sufficient accuracy for any plat.

In MINING SURVEYING also, the Trigonometer will be found of the greatest utility, especially where the workings are irregular, and vertical as well as horizontal angles have to be taken. In such cases, the calculation comprising two angles for every course, which would consume considerable time, is made as fast as the respective courses can be read and the results noted.

In MEANDERING streams, lakes or swamps the Trigonometer will be found a great help, as the results being absolutely correct, notes can be compiled with considerable dispatch.

The Engineer will find in his practice many other calculations, such as diagonals, slopes, stadia measurements, etc., all of which can be rapidly solved with this useful instrument, which, owing to the close and careful graduations of which it is capable, is a very desirable addition to an Engineer's or Surveyor's outfit, and one which should have its place in every engineering office.

The Mechanical Engineer, Builder and others will also find the Trigonometer of great assistance; as it gives at sight all the sides and angles of right-angled triangles, and with very little more labor the same particulars for any other triangles, the inclinations of roofs, the lengths of rafters and many other similar particulars may be at once obtained by it. It will also be found in many cases to replace advantageously the diagrams so frequently used for the purposes of calculation.

(To be continued.)



A CHEAP AND GOOD hectographic medium is made by dissolving one part of gelatine in an equal part of water and adding four parts of glycerine to the compound when it has become thoroughly homogeneous. This substance will maintain its special properties a very long time, and is on that account preferable to the cheaper formulæ which recommend common glue instead of glycerine.

THE COMPASS.

A Monthly Journal published the first of every month, at 127 Fulton Street, New York City.

WILLIAM COX, - - - - -	Editor.
KEUFFEL & ESSER CO., - - - - -	Publishers.

SUBSCRIPTION \$2.00 per year, in advance, postage paid. Single Copies, 20 Cents each.
CORRESPONDENCE should be addressed to the Editor of *THE COMPASS*, 127 Fulton Street, New York City.

All such bearing upon the topics to which the Journal is devoted, will be thankfully received and acknowledged with pleasure.

CONTENTS.

	PAGE.
Series of Numbers with Examples of their Practical Application to Scientific Purposes, - - - - -	129
Speedy Calculators, - - - - -	133
To our Readers, - - - - -	136
Finding the Decimal Point in using the Slide Rule, - - - - -	137
The Metric System, - - - - -	139
Engineering and Surveying Instruments, - - - - -	141

TO OUR READERS.

SPECIAL NOTICE.

WE HAVE RECEIVED from several of our subscribers gratifying tokens of the estimation in which our modest venture is held, which not only encourage us to continue the same, but also to give our readers every benefit which lies in our power. We have therefore decided with the first number of the next volume (August 1st, 1892), to reduce the subscription price to One Dollar a year, postage paid, maintaining for a time at least, its present size and number of pages. No subscriptions will be entered for less than one year.

To those of our present annual subscribers who have paid the full price of Two Dollars, we will either continue to send *THE COMPASS* free for another year, or if they prefer it, we will send them at their option a *Pump Indicator* or *Steam Pressure and Horse Power Indicator*, as described in the issues of August and November, 1891. This offer naturally does not apply to those who have already received one of these Indicators.

We shall continue to use every effort to make this monthly as popular, interesting and instructive as possible, and request the forbearance of

those who do not consider that it comes up to their ideal, reminding them that it addresses itself to students as well as to the more advanced members of the profession.

We should also be pleased if Engineers, Surveyors and others would make use of its columns for the purpose of ventilating theories, intercommunicating ideas and dispersing knowledge, useful and beneficial to themselves as a body and to the country at large. Its regular circulation is sufficiently important to secure for any such interchange of thought a considerable share of attention.

Subscriptions will be entered from this date, when so desired, to commence with the first number, on the terms named.



FINDING THE DECIMAL POINT IN USING THE SLIDE RULE.

BY F. A. HALSEY.

AS IS WELL KNOWN to all users of the slide rule, the chief annoyance connected with its use, particularly in continued multiplication and division, is the determination of the position of the decimal point. The following method, which I have used for years, surmounts the difficulty. I should add, lest I differ from you as to the lines to be used, that I use the *A* and *B* lines, finding them sufficiently accurate for ordinary work and avoiding the uncertainty as to which way the slide is to be moved. The following remarks apply to the *A* and *B* lines, but any user of the *C* and *D* lines will have no trouble in adapting the method to his practice.

In all multiplications the number of digits in the product is either the sum of the number of digits in the two factors or that sum less one. Thus in the first of the following examples:

311	411
31	41
311	411
933	1644
9641	16851

the number of digits in the first factor is 3 and in the second 2, while the number in the product is 4, that is $3 + 2 - 1$; whereas in the second example, while the number of digits in the factors is the same as before, the number in the product is 5, that is $3 + 2$.

It is only necessary to know under which case any given multiplication falls in order to know at once the number of digits and the position

of the decimal point in the product. In performing the multiplication $a \times b = c$ my procedure is as follows,

$$\begin{array}{l|l} A & \parallel \text{ Opposite } a \mid \text{ find } c \\ B & \parallel \text{ Set } 1 \mid \text{ opposite } b \end{array}$$

If this multiplication can be all performed upon the left hand scale of line A , it falls under the first case, but if both scales of A are required, it falls under the second case.

Similarly in division there are two cases, thus in $\frac{9641}{311} = 31$, the number of digits in the quotient is found by taking the number in the numerator, and from it subtracting one less than the number in the denominator, that is $4 - (3 - 1) = 2$, while in $\frac{16851}{411} = 41$, the number of digits in the quotient is found by taking the number in the numerator and from it subtracting the number in the denominator, that is $5 - 3 = 2$.

In performing the division $\frac{a}{b} = c$, my procedure is the exact reverse of that for multiplication, thus

$$\begin{array}{l|l} A & \parallel \text{ Find } c \mid \text{ opposite } a \\ B & \parallel \text{ opposite } 1 \mid \text{ Set } b \end{array}$$

As before, if this division can be all performed upon one scale of line A , it falls under the first case, but if both scales of line A are required, it falls under the second class.

In continued multiplication and division, that is in problems of this character,

$$\frac{a \times b \times c \times d}{e \times f \times g} = x$$

I proceed as follows:—Perform the multiplications as stated above, using the runner for each intermediate result. Whenever in any multiplication it is necessary to pass to the right the middle index of line A , turn down a finger of the left hand holding the rule. Then follow with the divisions in the manner stated. Whenever in any division it is necessary to pass the middle index of line A going to the left, straighten out a finger. Then set down the figures of the answer. To the number of digits of a add those of b less one, c less one and d less one; then subtract those of e less one, f less one and g less one. To this add as many as there remain fingers turned down, and the result is the number of digits in the answer.

I have used this method for years and find that it fills the bill.

NOTE.—The following are the rules which we have given in our MANUAL OF THE SLIDE RULE to be followed when using lines *C* and *D*. They will be found to agree with those stated by our Contributor.

	When the SLIDE projects to the	
	LEFT	RIGHT
	the CHARACTERISTIC of the RESULT is the	
MULTIPLICATION	{ Sum of the Characteristics of the 2 factors.	{ Sum — 1 of the Characteristics of the 2 factors.
DIVISION	{ Characteristic of Dividend, less char'c of Divisor.	{ Characteristic + 1 of Dividend less char'c of Divisor.

Editor THE COMPASS.

THE METRIC SYSTEM.

(Continued.)

PRESSURES.

<i>Exact Ratios.</i>	<i>Gauge Points or Equivalents.</i>
$1 = 0.07031$	$\frac{640 = \text{Pounds per square inch}}{45 = \text{Kilog's per square centimetre}}$
$1 = 4.8826$	$\frac{51 = \text{Pounds per square foot}}{249 = \text{Kilog's per square metre}}$
$1 = 0.54251$	$\frac{59 = \text{Pounds per square yard}}{32 = \text{Kilog's per square metre}}$
$1 = 5.17017$	$\frac{6 = \text{Pounds per square inch}}{31 = \text{Centimetres of mercury}}$
$1 = 0.7031$	$\frac{64 = \text{Pounds per square inch}}{45 = \text{Metres of water}}$
$1 = 0.48826$	$\frac{510 = \text{Pounds per square foot}}{249 = \text{Centimetres of water}}$
$1 = 34.54$	$\frac{11 = \text{Inches of mercury}}{380 = \text{Grammes per square centimetre}}$
$1 = 34.54$	$\frac{11 = \text{Inches of mercury}}{380 = \text{Centimetres of water}}$
$1 = 25.3959$	$\frac{26 = \text{Inches of water}}{660 = \text{Kilog's per square metre}}$
$1 = 304.7$	$\frac{21 = \text{Feet of water}}{6400 = \text{Kilog's per square metre}}$

$1 = 2.2413$	$\frac{29 = \text{Feet of water}}{65 = \text{Centimetres of mercury}}$
$1 = 1.034$	$\frac{59 = \text{Atmospheres}}{61 = \text{Kilog's per square centimetre}}$
$1 = 76.032$	$\frac{96 = \text{Atmospheres}}{730 = \text{Centimetres of mercury}}$
$1 = 10.34$	$\frac{59 = \text{Atmospheres}}{610 = \text{Metres of water}}$

COMBINATIONS.

$1 = 1.4882$	$\frac{43 = \text{Pounds per foot}}{64 = \text{Kilog's per metre}}$
$1 = 0.496$	$\frac{127 = \text{Pounds per yard}}{63 = \text{Kilog's per metre}}$
$1 = 16.019$	$\frac{49 = \text{Pounds per cubic foot}}{785 = \text{Kilog's per cubic metre}}$
$1 = 0.5933$	$\frac{27 = \text{Pounds per cubic yard}}{16 = \text{Kilog's per cubic metre}}$
$1 = 0.47192$	$\frac{89 = \text{Cubic feet per minute}}{42 = \text{Litres per second}}$
$1 = 0.0631$	$\frac{840 = \text{U. S. Gallons per minute}}{53 = \text{Litres per second}}$
$1 = 0.0757$	$\frac{700 = \text{Imp. Gallons per minute}}{53 = \text{Litres per second}}$
$1 = 0.1198$	$\frac{50 = \text{Pounds per U. S. gallon}}{6 = \text{Kilog's per litre}}$
$1 = 0.0998$	$\frac{10 = \text{Pounds per Imp. gallon}}{1 = \text{Kilog's per litre}}$
$1 = 28.315$	$\frac{3 = \text{Cubic feet of water}}{85 = \text{Weight in kilogrammes}}$
$1 = 3.7855$	$\frac{14 = \text{U. S. Gallons of water}}{53 = \text{Weight in kilogrammes}}$
$1 = 4.5435$	$\frac{46 = \text{Imp. Gallons of water}}{209 = \text{Weight in kilogrammes}}$
$1 = 18.287$	$\frac{41 = \text{Feet per second}}{750 = \text{Metres per minute}}$

1 = 0.3048	210 = Feet per minute
	64 = Metres per minute
1 = 18.287	41 = Feet per minute
	750 = Kilometres per hour
1 = 26.8219	19 = Miles per hour
	510 = Metres per minute
1 = 30.875	11 = Knots per hour
	340 = Metres per minute
1 = 0.1382	11 = Footpounds
	152 = Kilogrammetres
1 = 1.0136	147 = British Horse Power
	149 = Metric Horse Power

REMOVING LINES from drawings is generally accomplished by means of an erasing knife, which, however, is kept in order only with great difficulty. The following is a good means to overcome this difficulty and to save risk and labor: The blade of the knife is ground to a beveled edge and used with its blunt side towards the draughtsman, and the sharp side away from him. When erasing, the knife thus held will cut only in the direction from the operator, and not in the opposite direction. A knife thus ground can stand a considerable amount of vertical pressure without cutting into the paper, takes off fine parings and is easily re-ground.

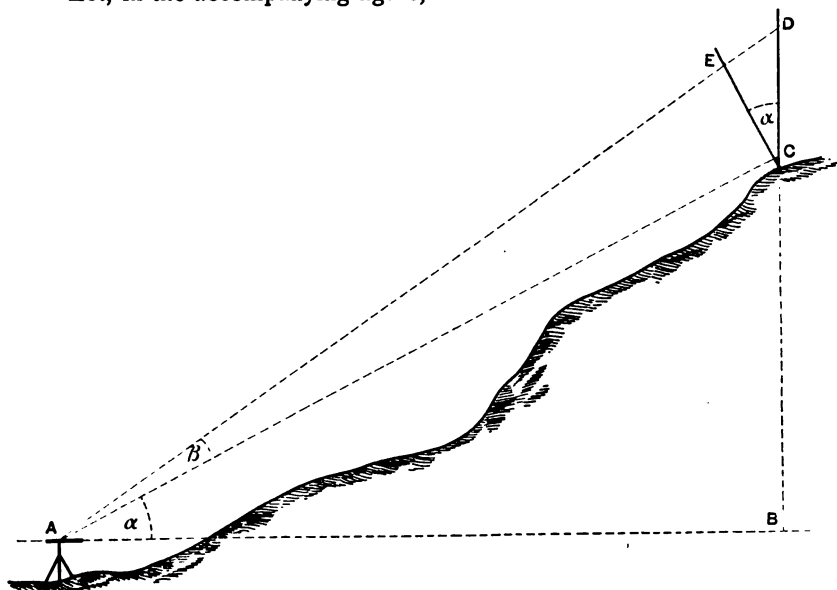
ENGINEERING AND SURVEYING INSTRUMENTS.

(Continued.)

THE TRANSIT.

THE METHODS OF USING the Gradiometer described in our last number apply only to cases where the ground is level, or very nearly so. It is often necessary, however, to take such measurements on inclined ground where the rod may be considerably above or below the horizontal line of sight. The mode of procedure is then quite altered and two methods are adopted according as the rod is held plumb, or perpendicular to the line of sight of the telescope. As it is easier and more usual for a rodman to hold his rod plumb than to incline it at the correct angle, we shall examine this method first.

Let, in the accompanying figure,



AB be the horizontal line of sight of the telescope ;

BAC be the angle of elevation of the telescope when directed to the foot C of the rod, as read upon the vertical limb $= \alpha$;

CAD be the angle covered by a given number n of revolutions of the gradienter screw $= \beta$;

CD be the length covered on the vertical rod, by n revolutions of the gradienter screw ;

CE be the length covered on a rod held perpendicular to the inclined line of sight AC , by n revolutions of the gradienter screw.

We have,

Angle $ECD = BAC = \alpha$ 1

and angle $BAD = \alpha + \beta$

whence angle $BDA = 90^\circ - \alpha - \beta$ 2

and angle $CED = 90^\circ + \beta$ 3

In the triangle CED , we have therefore

$$CE : CD :: \sin CDE : \sin CED$$

$$\text{or } CE : CD :: \sin (90^\circ - \alpha - \beta) : \sin (90^\circ + \beta),$$

$$\text{whence } CE = CD \frac{\sin (90^\circ - \alpha - \beta)}{\sin (90^\circ + \beta)}$$

$$\text{But } \sin (90^\circ - \alpha - \beta) = \cos (\alpha + \beta)$$

$$\text{and } \sin (90^\circ + \beta) = \cos \beta$$

$$\begin{aligned}
 \text{therefore } CE &= CD \frac{\cos(\alpha + \beta)}{\cos \beta} \\
 &= CD \frac{\cos \alpha \cos \beta - \sin \alpha \sin \beta}{\cos \beta} \\
 \text{or } CE &= CD (\cos \alpha - \sin \alpha \tan \beta) \dots\dots\dots 4
 \end{aligned}$$

We have previously shown that

Distance : 100 :: Rod reading : n turns of screw,

$$\text{whence } \frac{\text{Distance } AC}{\text{Rod reading } CE} = \frac{100}{n \text{ turns of screw}}$$

$$\text{so that } AC = CE \frac{100}{n}$$

$$\text{and as (Formula 4) } CE = CD (\cos \alpha - \sin \alpha \tan \beta)$$

$$\text{then } AC = CD \frac{100}{n} (\cos \alpha - \sin \alpha \tan \beta)$$

$$\text{But as } \frac{CE}{AC} = \tan \beta = \frac{n}{100}$$

$$\text{then } AC = CD \frac{100}{n} \left(\cos \alpha - \sin \alpha \times \frac{n}{100} \right)$$

$$\text{or } AC = CD \left(\frac{100}{n} \cos \alpha - \sin \alpha \right) \dots\dots\dots 5$$

$$\text{But } AB = AC \cos \alpha$$

and substituting formula 5 for AC ,

$$AB = CD \left(\frac{100}{n} \cos \alpha - \sin \alpha \right) \cos \alpha \dots\dots\dots 6$$

If we now take, as previously, 2 turns of the gradienter screw, or 1 division of the index to cover 1 foot on a rod at 100 feet distance, n becomes 1, so that we have

$$\text{Inclined Distance } AC = CD (100 \cos \alpha - \sin \alpha) \dots\dots\dots 7$$

$$\text{and Horizontal Distance } AB = CD (100 \cos \alpha - \sin \alpha) \cos \alpha \dots\dots 8$$

in which

AC = the inclined distance in a direct line from the centre of the telescope axis to the foot of a rod held plumb ;

AB = the horizontal distance from the centre of the telescope axis to a spot B immediately beneath the foot of the rod ;

CD = the space on the vertical rod covered by 2 turns of the gradienter screw, or one division of the index ;

α = the angle of elevation of the foot of the vertical rod above the horizontal line of sight passing through the axis of the telescope.

If the Gradienter is used for measuring heights, such as BC , then we proceed as follows :—

As before

$$A C = C D \left(\frac{100}{n} \cos \alpha - \sin \alpha \right) \dots\dots\dots 5$$

But $B C = A C \sin \alpha$,

therefore by substitution of above formula we have

$$B C = C D \left(\frac{100}{n} \cos \alpha - \sin \alpha \right) \sin \alpha$$

and taking n as before $= 1$,

$$B C = C D (100 \cos \alpha - \sin \alpha) \sin \alpha \dots\dots\dots 9$$

When the rod is placed below the horizontal line of sight, the points C and D are reversed, C then being at the top of the rod, and D at the bottom. The computation is however worked out in precisely the same manner as that described, due note being taken that the inclined distance then becomes $A C$ to the top of the rod.

In using the Gradienter, the screw should be set back a little and then turned continuously in the same direction when taking measurements, so that any lost motion in the screw may be taken up.

If the foot of the rod is held perpendicular to the line of sight, as $E C$, by means of the patent angle Target described in our previous issue, or by any other means, the length of the inclined distance $A C$ is obtained as on level ground; and this, multiplied by the cosine of the angle of elevation α , gives the length of the horizontal distance $A B$.

We have previously stated that the Gradienter Attachment may also be used for indirectly measuring angles of elevation. As one revolution of the gradienter screw covers a space of 0.5 foot at a distance of 100 feet, it follows that this is equivalent to

$$\frac{\text{Perpendicular } 0.5}{\text{Base } 100} = 0.005 = \tan \text{ of } 17' 11''.3$$

or, as one division of the index covers a space of 1 foot at a distance of 100 feet, this is equivalent to

$$\frac{\text{Perpendicular } 1}{\text{Base } 100} = 0.01 = \tan \text{ of } 34' 22''.7$$

In this way we are able to calculate the value of each revolution of the gradienter screw, each division of the index, and also the value of each one of the 50 divisions of the gradienter screw head.

The various calculations connected with the use of this valuable attachment to the Engineer's Transit, are much simplified by the use of tables. We shall therefore in our next issue give such, specially calculated for this purpose, by means of which inclined and horizontal distances, differences of elevation and angles of elevation may be easily computed, with examples showing the methods of using them.



"COPYRIGHT, 1891, BY WILLIAM COX, NEW YORK."

**A Monthly Journal for Engineers, Surveyors, Architects, Draughtsmen
and Students.**

Vol. I.

MAY, 1, 1892.

No. 10.

SPEEDY CALCULATORS.

(Continued.)

THE POLAR PLANIMETER.

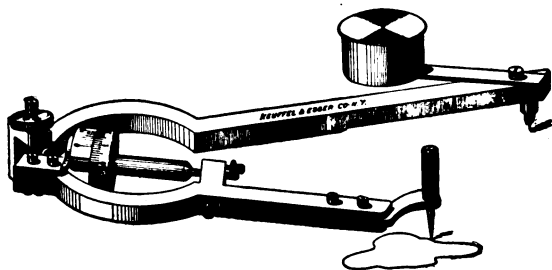


Fig. 1.

ONE OF THE MOST useful accessory instruments for the Mechanical as well as the Civil Engineer, and which may be termed a *Speedy Calculator*, is perhaps the POLAR PLANIMETER. The object of this ingenious device is to ascertain by mechanical means the area of any plane surface,

(however irregular its outline may be) such surface being represented by a figure drawn to a given scale. Planimeters vary considerably in the details of their construction, although they are all based on the same general principles. The simplest form is that shown in Fig. 1, it being specially designed for obtaining the areas of Steam Engine Indicator Diagrams. Other forms, modified and more complete, serve to ascertain the areas of railroad profiles and sections, plots of ground, sectional areas of vessels, areas of displacement of floating bodies, etc., and are indispensable to every Engineer. With these latter, the drawings may generally be made to any scale, and by adjusting one of the arms accordingly, the area will be obtained in terms of the original plot.

The **FIXED PLANIMETER**, Fig. 1, consists mainly of two arms pivoted together, and a small wheel; one of the former is provided with a needle point at its end, intended to serve as a fulcrum, while the other arm has at its extremity a tracing point, whose movements are registered by means of the wheel. This wheel is divided on a portion of its circumference into 10 primary equal divisions, each one of which represents an area of 1 square inch; these are again subdivided into 10 equal parts each, so that with the aid of the vernier attached to the tracer arm, inches, tenths and hundredths of an inch may be read off.

When the instrument is about to be used, the needle should be pressed gently into the drawing board in a convenient position near the drawing whose area is required, and the small weight placed on the extension bar, so that all the parts being balanced, the tracer and the wheel may rest lightly on the drawing without undue straining, the wheel being made to revolve in accordance with the varied movements of the tracer.

The tracing point is then set on the outline of the diagram or drawing, and a slight indentation made in the paper to indicate the starting point. Having noted the reading of the wheel and vernier, the tracer is made to gently follow, as exactly as possible, and always in the direction of the hands of a watch, the outline of the figure. When the tracer has reached the starting point, the reading of the wheel and vernier is again noted, and the first reading deducted from the second; the remainder will then be the required area in square inches and hundredths.

EXAMPLE :—Required the area of an indicator diagram in square inches and hundredths.

Assume that when the tracer is placed on the top left hand corner of the diagram, the wheel indicates.....	3.70
and the vernier “ 	0.05

First Reading = 3 75

Having gone round the diagram, we now find that the wheel indicates 6.20
and the vernier " 0.08

Second Reading = 6.28

Subtracting the first reading 3 75

Difference = 2.53

square inches, which is the actual area of the diagram.

To find the mean pressure of the steam, we divide the area by the length between the terminal points of the diagram; thus, supposing the length to be 3.82 inches, the mean height will be $\frac{2.53}{3.82} = 0.662$ inches.

If the spring used in the Indicator be a No. 40, (equivalent to 40 pounds pressure per inch of height) then the mean pressure indicated would be equal to the product of the mean height of the diagram and the number of the spring, or $40 \times 0.662 = 26.48$ pounds per square inch.

It will be seen that the FIXED PLANIMETER, Fig. 1, is peculiarly suited to the measurement of Indicator diagrams as shown in the example, as its wheel does not record beyond 10 square inches, this being amply sufficient in practice. Fig. 2 represents a similar instrument, but in order to render it suitable for somewhat larger areas, a small horizontal

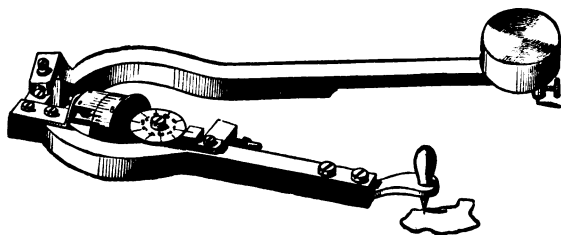


Fig. 2.

disc is provided, which by means of a worm on the wheel axis, records the complete revolutions of the wheel. As the disc is divided on its circumference into 10 equal parts, this Planimeter registers up to 100 square inches.

If the instrument is used for obtaining the area of small plots of land, drawn to a particular scale, then the area obtained in square inches must be multiplied by the square of the ratio of the plot to the scale of the drawing, or by the square of the number of units to the inch.

EXAMPLE:—Required the area of a plot shown on a plan drawn to a scale of 5 feet to an inch. Assuming that the disc, wheel and vernier readings are respectively

Second.....	89.78
First.....	22.34

then Difference = 67.44 square inches is the actual area of the drawing, which being made to a scale of 1 in = 5 feet, or 1 : 60, gives for the area of the plot

$$67.44 \times 60 \times 60 = 242,784 \text{ sq. in} = 1686 \text{ sq. feet,}$$

$$\text{or } 67.44 \times 5 \times 5 = 1686 \text{ square feet.}$$

The usefulness of the Fixed Planimeter is restricted by two considerations, first, its small size and the consequent limited areas which can be measured; and second, the record being invariably given in square inches.

The PROPORTIONAL PLANIMETER has been devised to overcome both these objections, and that special form of the instrument which we shall describe in our next, will, we believe, be found to satisfy every requirement.

The accuracy of the measurements made with the Planimeter depends upon the care exercised in passing the tracer round the outline of the figure whose area is required, and also upon the construction and adjustment of its various parts. To test the latter, take the tracer round a given figure and note the readings, then repeat the operation in the opposite direction, and if the readings agree, the instrument is in adjustment. If there should be a difference, the tracing point is not in perfect line with the axis of the wheel, and requires to be so set by means of the two screws by which the tracer is attached to the arm; or the wheel axis may not be perfectly parallel to the tracer arm in which case it must be so adjusted.

The instruments which we have described are of the best quality and workmanship, and may be fully relied upon. Their form will be found most convenient, and preferable to those in which the wheel is placed outside the tracer arm, thus rendering it more liable to accidents. The Planimeter should be handled with care, and the bright surface of the wheel preserved intact.

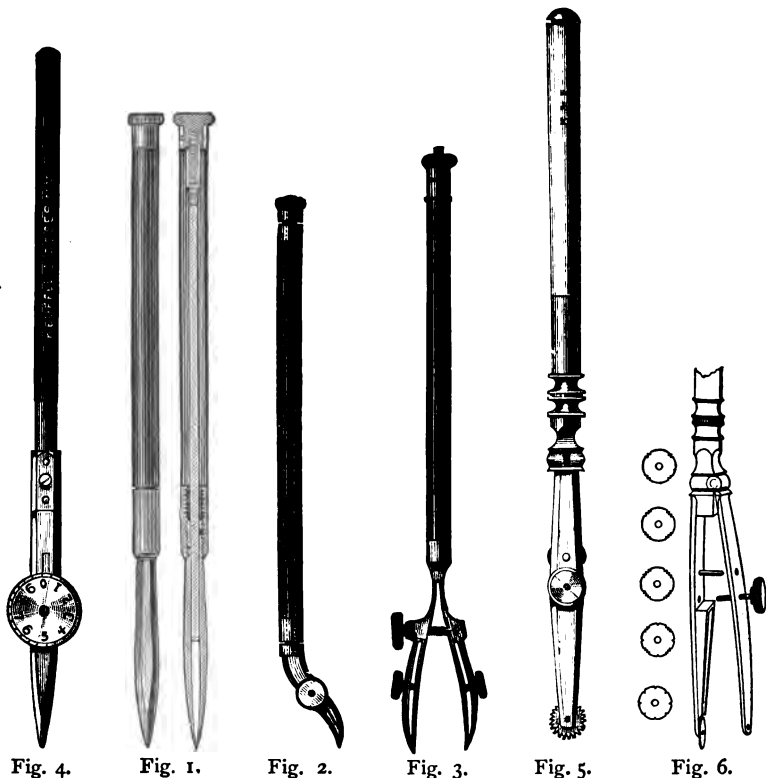
(To be continued.)



WE COMPLY WITH suggestions recently received, and enclose with the present issue a list of prices of Slide Rules, Calculating and other instruments, descriptions of which have been given in THE COMPASS. We purpose adopting such a course more frequently in the future, as we gather from the number of letters received asking for such information, that our readers not only appreciate the descriptions of instruments, etc., given, but would very often be more interested if the prices accompanied them.

AN ASSORTMENT OF HANDY INSTRUMENTS FOR
THE DRAUGHTING ROOM.

(Continued.)



PARAGON DRAWING INSTRUMENTS, referred to in the first number of THE COMPASS, possess all the requirements of quality, grace, symmetry and accuracy of their parts, and finish, to meet the demands of the most scrupulous, and to enable the draughtsman to work with pleasure and satisfaction, especially when he regards the clearness and exactitude of the results of his labors. There are, however, a few other Drawing Pens which he may find useful, and which will help to make his collection complete. We here refer to their special disposition and not to their quality or finish, as the PARAGON Drawing Pens are in this respect admittedly as perfect as they can be.

A Drawing Pen specially adapted for *fine* work will be often found very useful. Such an one should have nicely tapered blades, not too

rounded so as to obstruct the view of the drawing and prevent a clean start or ending of a line to be made, instead of a definite and decided one. We present to our readers such a pen in Fig. 1, from which it will be at once noticed that there is no screw for adjusting the points, which is of itself a great advantage, as there is thus no obstruction to the sight when working. The pen is opened by turning the small thumbscrew at the upper end of the handle to the left, which pushes a small rod between the blades, thus spreading them out; by turning the thumb-screw in the opposite direction, this rod is withdrawn into the handle and the points close together of themselves, making a fine point capable of producing the most delicate lines. By this ingenious arrangement the nibs can never be displaced sideways. We are sure that this Drawing Pen will be welcomed by all those who admire clear, delicate work. It is also most agreeable to work with, is cleanly and admits of careful adjustment of the blades.

The Curve Pen shown in Fig. 2 is specially adapted for tracing curved lines; it has a hollow handle in which a small rod turns, to the end of which the blades are fastened, and these being eccentric to it, turn easily and follow the smallest curve with precision. When required, the handle can be clamped by means of a small nut at the upper end of the rod, so that it may be used as a common drawing pen.

Figure 3 shows a pen constructed on the same principles, but provided with two pairs of blades for railroad and other similar work. The heads of the screws in the blades are graduated to permit of uniform adjustment of the two pens being obtained. The screw of the Curve Pen, Fig. 2, is also similarly graduated, and in such manner that the same setting in these two pens will produce lines of the same thickness.

Figure 4 represents a Drawing Pen with a graduated thumb-screw, by means of which the blades may be set as often as required to produce lines of the same degree of fineness. This will be found useful when lines of recurring thicknesses have to be made, and in which uniformity is to say the least, desirable. It will be also found extremely useful for shading, as by advancing the screw one division at a time, each succeeding line can be made a little finer than the previous one, the differences being uniform. The thumb-screw is held in position by means of a spring falling into grooves on the under side of the screw-head, corresponding with the graduations of its upper surface.

A good Dotting Pen is a desideratum often called for, especially one in which the ink will not run and blur the drawing. Such an one is shown in Fig. 5. The inner surface of the under blade is surrounded with a thin metal edging, thus forming a reservoir for the ink, seen in Fig. 6, which is filled by means of a camel-hair brush. The blades are then brought together by the thumb-screw, thus closing in the reservoir on all sides except

a narrow space at the bottom, through which the ink flows to the dotting-wheel, the requisite quantity being supplied and no more, consequently entirely preventing blotting. This dotting pen has six wheels with which different patterns of dotted lines can be produced ; they are held between the upper parts of the blades. Care must be exercised in the use of this as of all similar pens, and the pen should always be kept in a state of perfect cleanliness, so that the ink may be sufficiently maintained in the reservoir by reason of its adhesion to the sides.

(To be continued)

THE "COMFORT" DRAWING TABLE.

AN EASY POSITION when drawing is essential to the production of good work, and necessary if health is to be taken into consideration. That many suffer seriously from working upon a low flat table is well known, while others avoid to some extent the evil by using a moderately high table with sloping top. To obviate *entirely* however, the inconveniences of a stooping position, the Drawing Table, illustrated on page 160 has been brought out, and we may say that those who have tried it are unanimous in affirming that it well deserves the name THE COMFORT which has been given to it.

The frame holding the drawing board is counter-balanced, so that it may be adjusted with ease to any height, thus bringing all portions of the drawing *immediately in front* of the draughtsman, whether sitting or standing.

It is provided with a Parallel Ruler, which is also counter-balanced, and will remain perfectly steady in any position in which it may be placed, thus serving both as a T square and straightedge. A large inclined table with a lock-drawer is fixed to the iron frame behind the board, while a commodious receptacle for tools, etc., is attached to the lower front edge of the drawing board frame. The illustration shows a drawing board measuring 46x67 inches.

It will be found, with a little practice, as easy to draw on this upright table as on a flat one, lines can be inked in with the same facility, and round writing, owing to the manner in which the pen is held, is as easy as if the draughtsman were sitting at an ordinary desk or table. The COMFORT DRAWING TABLE will be found particularly advantageous for Detail Drawing, whilst in architectural designs, the harmony of the parts and the general effect of the whole, can be much better appreciated as the work advances, than on a flat table. Another great advantage will be found in the small amount of space it takes up in the draughting room, and the facility of placing several of them in suitable positions as regards the light.

THE COMPASS.

A Monthly Journal published the first of every month, at 127 Fulton Street, New York City.

WILLIAM COX, - - - - - Editor.

KEUFFEL & ESSER CO., - - - - - Publishers.

SUBSCRIPTION \$1.00 per year, in advance, postage paid. Single Copies, 10 Cents each.

CORRESPONDENCE should be addressed to the Editor of THE COMPASS, 127 Fulton Street, New York City.

All such bearing upon the topics to which the Journal is devoted, will be thankfully received and acknowledged with pleasure.

CONTENTS.

	PAGE.
Speedy Calculators, - - - - -	145
An Assortment of Handy Tools for the Draughting Room, - - - - -	149
The "Comfort" Drawing Table, - - - - -	151 and 160
Series of Numbers with Examples of their Practical Application to Scientific Purposes, - - - - -	152
Engineering and Surveying Instruments, - - - - -	156

SERIES OF NUMBERS WITH EXAMPLES OF THEIR PRACTICAL APPLICATION TO SCIENTIFIC PURPOSES.

(Continued.)

ANOTHER, AND SIMPLE, because more practical method of obtaining the position of the points B , $C D$, etc., or the lengths of the radiants $P B$, $P C$, $P D$, etc., is by means of proportional dividers. Let, for example, the semi-circle $A C' E$ be divided into 10 equal parts, and let it be required that the ratio of the first radiant $P A$ shall be to the second radiant, as 9 is to 10. Having set the slider of the dividers to the graduation $\frac{9}{10}$ of the *Scale of Lines* (as described in the September number of THE COMPASS), take in between the points of the smaller end a distance equal to 9 parts by any suitable scale, and with this lay off the distance $P A$; then with the opening at the other end of the dividers, which will be equal to 10 such equal parts, lay off from P on the second radiant the required distance to the point of its intersection with the curve. Now take in the narrow end of the dividers this latter distance, and with the broad end lay off in the same manner on the third radiant the distance from P to the point of intersection of the curve. Having proceeded in this way with all the radiants, trace the curve through these different points of intersection, when it will be found that the ratio between any two con-

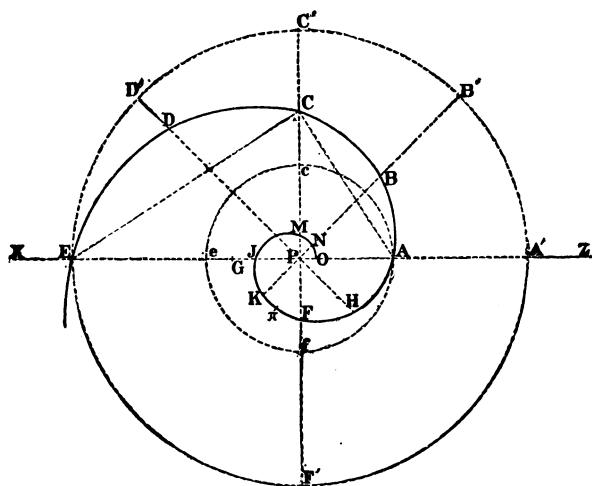


Fig. 1.

secutive, alternative or equally distanced radiants is the same, thus satisfying the requirements of a true Logarithmic Spiral Curve.

Such are the different methods by means of which such a curve may be constructed; the practical application of its remarkable properties requires, however, that it be made with extreme accuracy and that the material employed should not be apt to warp or shrink. The best curves are made of Hard Rubber, as it less liable to be affected by changes of temperature, the state of the atmosphere, etc.; they are also made of celluloid, but for the reasons already given in a previous issue (Decbr.) we cannot recommend them. The curves sold by the publishers of THE COMPASS measure 10 millimetres from P to O , 23.68 $\frac{m}{m}$ from P to J , 56.08 $\frac{m}{m}$ from P to A and 132.8 $\frac{m}{m}$ from P to E . Tables are supplied with them giving the lengths of the various radiants from O to E , the included angle between each successive one being 5 degrees, thus making 72 radiants in a complete circle.

Having described the principles and mode of construction of this peculiar curve, we now proceed to examine some of its uses. Its adaptation to the finding of the Average Pressure of Steam in an Engine Cylinder with any cut off has already been described. The principles upon which its construction depends being the same as those belonging to the Slide Rule, it is not surprising that it may be used in much the same manner. For purposes of calculation, take a drawing board, with a sheet of clean paper stretched upon it, and draw the straight line XZ , and from point P in the centre mark off towards Z any suitable scale of equal parts. Take a strip of cardboard with a similar scale marked along one edge, and then pass a fine needle through the centre of the curve, through the zero

of the loose scale and through P , so that the two former may revolve freely round this point.

Now turn the curve round until the distance PA on the scale PZ shall be equal to, say 70 parts, then turn the loose scale round until the radiant, which it represents, shall measure 64 similar parts from P to the edge of the curve. This ratio of 70 to 64 is that existing between a yard and a metre. If the loose scale be now held steadily in the same position, and the curve turned round, so that it shall intersect any other number on the fixed scale or radiant PZ , say 150, then the division of the movable scale intersected by the curve will bear the same ratio to 150 that 70 does to 64, or $\frac{150 \times 64}{70} = 137$, so that 137 Metres is equivalent to 150 yards.

To simplify reference for future use, a line may be drawn on the edge of the sheet of paper to which the movable scale should be set, so that the same ratio may be at once obtained whenever required. The same mode of procedure may be followed with any other ratios which are of frequent use, and if they are marked on a sheet of Bristol Board, they will serve for a long time and be found very useful for purposes of calculation.

It will be at once seen how similar are the principles and use of this instrument to those of the Slide Rule, the fixed scale PZ representing the scale D of the latter, while the movable scale takes the place of scale C of the slide.

Multiplication and division being but other forms of proportion, it naturally follows that this curve may be used for such operations. Thus, let it be required to multiply 78 by 145.3.

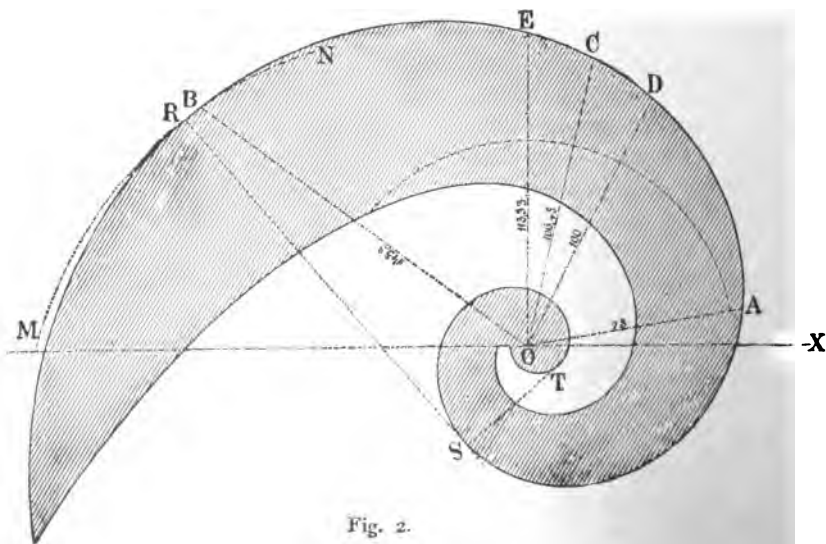


Fig. 2.

Take OA to be, according to a suitable scale, equal to the factor 78, and OB to be by the same scale equal to the factor 145.3. Bisect the Angle AOB so that Angle $AOC = \text{Angle } COB$, then $OC^2 = OA \times OB$. Now take by the same scale $OD = 100$, and make Angle $COE = \text{Angle } COD$, whence it follows that

$$OC^2 = OE \times OD, \text{ and consequently}$$

$$OA \times OB = OE \times OD$$

Now OE is found by the same scale to be equal to 113.33, therefore

$$OA \times OB = 113.33 \times 100$$

$$= 113, \text{ which is the product of } 78 \text{ and } 145.3$$

The above process may be simplified by taking one factor on the horizontal line OX and moving the loose scale to the required position of the other factor. If the Bristol Board has a scale of degrees marked round its edges, the bisection of the angles can be made with very little trouble, and the loose scale then turned to this and the other necessary points, or the edges of the curve itself might be similarly graduated.

The Logarithmic Spiral Curve will also be found very useful for the following purposes:—

1. Owing to the curvature gradually changing, it can be applied to any part of a given curve.
2. It assists in rapidly determining the *centre of curvature* of a given curve. If, for instance, the instrument coincides with the curve MN at

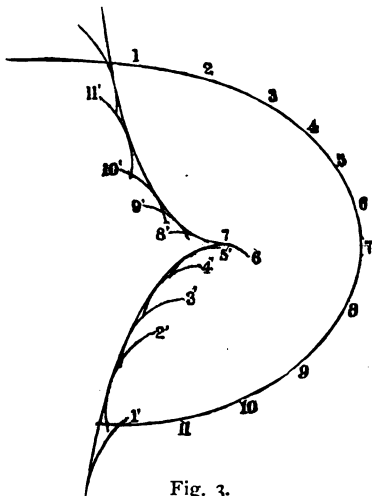


Fig. 3.

R , Fig. 2, then the line RS , which is a tangent to the spiral at S , gives the direction of the *true radius* of curvature of the point R of the curve MN , while the tangent ST , at right angles to RS , gives the exact position of the centre S of curvature.

3. For drawing the evolute of a curve, (the curve FK , Fig. 1, is the evolute of the curve DE) the instrument is fitted to a series of points, 1, 2, 3, . . . of the curve, each time drawing with the same a short piece of the curve containing the centre of curvature, $1^1, 2^1, 3^1$

. . . , which pieces then surround the evolute of the given curve.

(To be continued.)

ENGINEERING AND SURVEYING INSTRUMENTS.

(Continued.)

THE TRANSIT.

GRADIENTER TABLE. I.*

* "Copyright 1892, by William Cox, New York."

Angle of Elevation.	Inclined Distance. (100 cos α — sin α)	Horizontal Distance. (100 cos α — sin α) cos α	Vertical Distance. (100 cos α — sin α) sin α	Angle of Elevation.	Inclined Distance. (100 cos α — sin α)	Horizontal Distance. (100 cos α — sin α) cos α	Vertical Distance. (100 cos α — sin α) sin α
0				0			
1 00	99.968	99.953	1.744	12	97.607	95.474	20.293
1 30	99.940	99.906	2.616	10	97.543	95.352	20.558
2	99.904	99.843	3.487	20	97.478	95.229	20.821
2 30	99.861	99.767	4.356	30	97.414	95.105	21.084
3	99.811	99.674	5.224	40	97.347	94.977	21.346
3 30	99.752	99.565	6.090	50	97.280	94.850	21.608
4	99.686	99.443	6.954	13	97.212	94.721	21.868
4 30	99.614	99.307	7.816	10	97.143	94.589	22.127
5	99.532	99.153	8.675	20	97.073	94.456	22.387
5 30	99.444	98.987	9.532	30	97.004	94.323	22.645
6	99.347	98.803	10.385	40	96.933	94.189	22.902
6 30	99.244	98.606	11.234	50	96.861	94.052	23.159
7	99.133	98.395	12.081	14	96.788	93.913	23.415
7 30	99.013	98.166	12.924	10	96.714	93.773	23.670
8	98.888	97.926	13.762	20	96.639	93.631	23.924
8 30	98.754	97.670	14.597	30	96.565	93.489	24.178
9	98.613	97.399	15.426	40	96.489	93.345	24.431
9 30	98.464	97.114	16.251	50	96.411	93.198	24.682
10	98.307	96.814	17.071	15	96.334	93.052	24.933
10	98.253	96.711	17.343	10	96.255	92.903	25.183
20	98.199	96.606	17.614	20	96.176	92.752	25.432
30	98.143	96.499	17.886	30	96.096	92.601	25.681
40	98.087	96.392	18.155	40	96.015	92.448	25.928
50	98.030	96.283	18.425	50	95.933	92.293	26.174
11	97.972	96.172	18.694	16	95.850	92.137	26.420
10	97.913	96.060	18.962	10	95.768	91.981	26.665
20	97.853	95.945	19.230	20	95.683	91.821	26.909
30	97.793	95.829	19.497	30	95.598	91.661	27.152
40	97.732	95.713	19.763	40	95.512	91.500	27.393
50	97.670	95.594	20.029	50	95.425	91.336	27.634
12	97.607	95.474	20.293	17	95.338	91.171	27.874

Angle of Elevation.	Inclined Distance. (100 cos α — sin α)	Horizontal Distance. (100 cos α — sin α) cos α	Vertical Distance. (100 cos α — sin α) sin α	Angle of Elevation.	Inclined Distance. (100 cos α — sin α)	Horizontal Distance. (100 cos α — sin α) cos α	Vertical Distance. (100 cos α — sin α) sin α
0				0			
17	95.338	91.171	27.874	24	90.948	83.086	36.392
10	95.250	91.006	28.113	10	90.827	82.867	37.184
20	95.161	90.840	28.351	20	90.704	82.646	37.374
30	95.071	90.671	28.589	30	90.581	82.425	37.563
40	94.981	90.501	28.825	40	90.458	82.203	37.752
50	94.889	90.329	29.060	50	90.333	81.980	37.938
18	94.797	90.158	29.294	25	90.208	81.757	38.124
10	94.703	89.982	29.527	10	90.082	81.530	38.307
20	94.609	89.807	29.758	20	89.955	81.304	38.490
30	94.515	89.630	29.990	30	89.828	81.078	38.672
40	94.420	89.453	30.220	40	89.700	80.849	38.852
50	94.323	89.273	30.449	50	89.571	80.620	39.031
19	94.226	89.093	30.677	26	89.440	80.388	39.208
10	94.129	88.911	30.904	10	89.311	80.158	39.384
20	94.030	88.728	31.130	20	89.179	79.925	39.559
30	93.930	88.542	31.355	30	89.047	79.691	39.733
40	93.830	88.357	31.579	40	88.914	79.456	39.905
50	93.729	88.169	31.801	50	88.781	79.221	40.076
20	93.627	87.980	32.022	27	88.647	78.985	40.245
10	93.524	87.790	32.242	10	88.511	78.747	40.413
20	93.422	87.600	32.462	20	88.376	78.509	40.580
30	93.317	87.407	32.680	30	88.239	78.269	40.744
40	93.212	87.214	32.897	40	88.102	78.028	40.908
50	93.106	87.019	33.113	50	87.964	77.788	41.070
21	93.000	86.823	33.328	28	87.826	77.546	41.231
10	92.892	86.625	33.541	10	87.686	77.302	41.391
20	92.784	86.427	33.754	20	87.545	77.057	41.549
30	92.676	86.227	33.966	30	87.405	76.813	41.706
40	92.566	86.026	34.176	40	87.263	76.567	41.861
50	92.455	85.823	34.385	50	87.121	76.320	42.015
22	92.343	85.619	34.593	29	86.977	76.072	42.167
10	92.232	85.415	34.799	10	86.834	75.824	42.318
20	92.119	85.209	35.004	20	86.688	75.573	42.468
30	92.005	85.002	35.209	30	86.544	75.324	42.616
40	91.891	84.793	35.412	40	86.397	75.072	42.762
50	91.776	84.584	35.614	50	86.251	74.821	42.908
23	91.659	84.372	35.814	30	86.103	74.568	43.052
10	91.543	84.161	36.014	10	85.954	74.314	43.194
20	91.426	83.949	36.212	20	85.805	74.058	43.334
30	91.307	83.734	36.409	30	85.655	73.803	43.474
40	91.189	83.520	36.604	40	85.505	73.547	43.611
50	91.068	83.302	36.799	50	85.353	73.290	43.747
24	90.948	83.086	36.992		85.202	73.033	43.882

The above table gives the values of the factors

$$(100 \cos \alpha - \sin \alpha) \dots \text{ in Eq. 7.}$$

$$(100 \cos \alpha - \sin \alpha) \cos \alpha \quad \text{“} \quad 8.$$

$$\text{and } (100 \cos \alpha - \sin \alpha) \sin \alpha \quad \text{“} \quad 9.$$

so that all that is required to be done to obtain the Inclined, Horizontal and Vertical Distances, AC , AB and BC , is to multiply the rod reading CD by the values corresponding to the angle α , thus:

Let angle $\alpha = 14^\circ 40'$, and $CD = 4.78$ for two revolutions of the screw, or one division of the index; then we have according to the table

$$AC = 4.78 \times 96.489 = 461.217 \text{ feet.}$$

$$AB = 4.78 \times 93.345 = 446.189 \quad \text{“}$$

$$BC = 4.78 \times 24.431 = 116.780 \quad \text{“}$$

When the angle α is not given in the table, we proceed as in the following example:—

Let the $\alpha = 21^\circ 45'$, and $CD = 5.42$ for one division of the index, then according to the table,

$$\text{Value of factor for inclined distance for } 21^\circ 40' = 92.566$$

$$\text{“ “ “ “ “ } 21^\circ 50' = 92.455$$

$$\text{Difference for } 10' = 0.111$$

$$\text{and “ “ } 5' = 0.055$$

whence factor for $21^\circ 45' = 92.510$, so that Inclined Distance AC
 $= 5.42 \times 92.510 = 501.40 \text{ feet.}$

Likewise,

$$\text{Value of factor for horizontal distance for } 21^\circ 40' = 86.026$$

$$\text{“ “ “ “ “ } 21^\circ 50' = 85.823$$

$$\text{Difference for } 10' = 0.203$$

$$\text{and “ “ } 5' = 0.101$$

whence factor for $21^\circ 45' = 85.924$, so that Horizontal Distance AB
 $= 5.42 \times 85.924 = 465.71 \text{ feet.}$

Again,

$$\text{Value of factor for vertical distance for } 21^\circ 50' = 34.385$$

$$\text{“ “ “ “ “ } 21^\circ 40' = 34.176$$

$$\text{Difference for } 10' = 0.209$$

$$\text{and “ “ } 5' = 0.104$$

whence factor for $21^\circ 45' = 34.28$, so that Vertical Distance BC
 $= 5.42 \times 34.28 = 186.20 \text{ feet.}$

We have preferred calculating the table to 3 places of decimals, so as to insure greater accuracy in the results of such measurements; where this is not necessary, the third decimal may be omitted in the multiplication.

In our next we shall give a table whereby the angular value of each division of the screw, as well as of each division of the index, may be obtained, also a table by means of which small vertical angles may be set off. These tables will be calculated on the basis of strict tangents, and not on the general assumption that the angular value of each division of the screw and of the index is the same throughout, which method leads to an increasing error as the angle is greater. In this connection it may be well to state that the central division of the index is usually marked zero, this being the only position of the gradienter arm in which the screw is exactly tangential to the circle which it describes. In this way the error, or the *difference between the values of a circumferential and a tangential index*, as we may term it, is reduced to an almost inappreciable quantity. We here give in tabular form the angular values of each division of the index, according to the two modes of computation, from which the amount of error is at once seen.

Divisions of Index.	CIRCUMFERENTIAL INDEX. <i>Equal values for all divisions.</i>			TANGENTIAL INDEX. <i>Decreasing value for each succeeding division.</i>			Differences.	
	0	'	"	0	'	"	'	"
1	0	34	22.65	0	34	22.55	0	00.10
2	1	08	45.30	1	08	44.74	0	00.56
3	1	43	07.94	1	43	06.18	0	01.76
4	2	17	30.59	2	17	26.30	0	04.29
5	2	51	53.24	2	51	44.79	0	08.45
6	3	26	15.89	3	26	01.23	0	14.66
7	4	00	38.54	4	00	15.15	0	23.39
8	4	35	01.18	4	34	26.21	0	34.97
9	5	09	23.83	5	08	33.99	0	49.84
10	5	43	46.48	5	42	38.16	1	08.32

We recommend that the Gradienter be so used as to distribute as far as possible the measurements equally on both sides of the Index zero, as by this mode the error named will be eliminated, or very nearly so.

(To be continued.)



THE "COMFORT" DRAWING TABLE.

(See Page 151).



"COPYRIGHT, 1891, BY WILLIAM COX, NEW YORK."

**A Monthly Journal for Engineers, Surveyors, Architects, Draughtsmen
and Students.**

Vol. I.

JUNE, 1, 1892.

No. 11.

WARD'S ENGINEER'S TAPE.



Patented August 21, 1877.

THE SETTING OF Slope Stakes always necessitates a greater or lesser number of trials and approximations, in order to determine the *distance out* of the point of intersection of the natural surface of the ground and the slope of the cut or fill, and any means whereby these operations may be lessened or simplified is a step in the right direction.

The EXCELSIOR Engineer's Tape, known as Ward's Patent, will be found very useful for the above named purpose. It is an *all linen* tape,

50 yards long, in bent leather case, with folding handle. One side of the tape is marked in feet and tenths, as for ordinary measurements, while the other side is marked in a special manner for setting Slope Stakes, or for finding the centre from the Slope Stakes, after the Centre Stake has been removed. Half the width of the proposed road-bed (say 9 feet if for single track, and 14 feet if for double track) is laid off from the ring end of the tape, and divided into feet and half-feet; these are numbered backward from the ring, so that the 9th or the 14th foot from the end of the tape becomes Zero. Beyond this Zero the marking is continued in the usual manner, but the unit of measurement is $1\frac{1}{2}$ feet, which corresponds to the base of a slope $1\frac{1}{2}$ to 1. Each unit is divided into 10 equal parts, and the whole is marked in a different color and style from the other side of the tape, to prevent any possible confusion of the two scales.

In setting the slope stakes with this tape, the tape-ring being held at the centre stake, it is evident that the distance out must be by this scale (unit of $1\frac{1}{2}$ feet) the same as the vertical height of the fill by the ordinary scale (unit of 1 foot). The distances out are therefore easily obtained without any calculation, thus not only saving time, but also diminishing the chances of error.

These tapes are made for road-beds of 28 feet width and slopes of $1\frac{1}{2}$ to 1, and can be used for any road-bed of less width, and also for wider ones, by temporarily attaching a piece of tape or string of the required extra length to the tape ring.

A small pamphlet, *How to Set Slope Stakes*, giving full particulars of the method of using this Tape, can be had from the Publishers of THE COMPASS, and is also supplied with each one of the above Tapes.

SPEEDY CALCULATORS.

(Continued.)

THE POLAR PLANIMETER.

WE STATED IN OUR LAST that the Fixed Planimeter records the actual area of a figure, drawing or diagram, in square inches, which may be reduced, if necessary, so as to give the actual area of the plot, by multiplying the wheel record by the square of the number of units per inch of the scale of the drawing. The proportional Planimeter gives however the record in terms (equal, fractional or multiple) of the original plot, such as square yards, square chains, acres, square miles, etc. The Planimeter illustrated herewith will be seen to consist in the main of the same parts

the theory of this instrument, a knowledge of which is not essential to the facile and intelligible use of this valuable calculator. It is however, necessary to understand thoroughly the method of obtaining *Settings* of the Tracer Arm. These adjustments, which are equivalent to the Gauge Points employed with the Slide Rule, may be ascertained by two different methods, by computation or by means of a round brass trial disc furnished with each instrument, having a circumferential grooved rim inclosing a known area, around which the tracer can be carried with exactitude. The latter is the simplest as well as the most reliable method, as for the former it is necessary to know with mathematical accuracy the length from the tracer to the pivot *J* and also the circumference of the recording wheel.

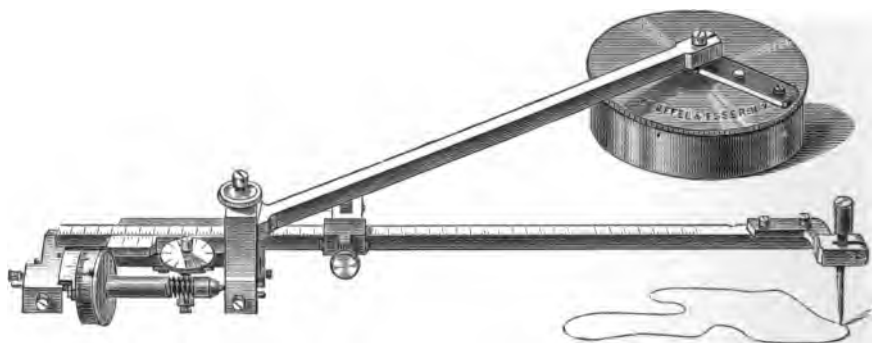


Fig. 2.

Drawings and plans are always made to a given scale, as $1 : 10$, $1'' = 1$ foot, 40 inches to a mile, etc. As any value may thus be given to a linear inch of the drawing, that is, to the unit of measurement of such plan or map, so any value may be *assigned* to the *thousandth part* of a revolution of the wheel, that is, the unit of measurement of the Planimeter, called the *wheel unit* (sometimes also the vernier unit), and therein lies the special advantage of the PROPORTIONAL Planimeter, as may be gathered from the following examples.

Take a map or plan drawn to a scale of $1 \text{ inch} = 50 \text{ feet}$, and let the tracer go round an exact area of 1 square inch of the map. If the arm be properly set, we shall have a record of 100 units, or $\frac{100}{1000}$ ths of a revolution of the wheel. If therefore we *assign* to each of these wheel units a value of 25 square feet, we have as the resulting record $100 \text{ units} \times 25 \text{ square feet} = 2500 \text{ square feet}$, which is the actual surface of the plot of land represented on the map by one square inch, that is, according to the scale, $50 \times 50 = 2500 \text{ square feet}$.

Now suppose we take the same setting and assign to each wheel unit a value of 1 square chain, and that our map is made to a scale of 8 inches

= 1 mile, then our record, as before, will be 100 units or 100 square chains, which will be the real area corresponding to one square inch of the map, for if 8 inches = 1 mile, then 1 inch = $\frac{1}{8}$ mile = 10 chains, and 1 square inch = $10 \times 10 = 100$ square chains.

In this way, by varying the settings of the tracer arm, and the value of the wheel unit, the recording results may be obtained in terms of the original plot of land, *whatever may be the scale of the map or drawing*. We say in terms of the original, but by this we do not mean that they will be invariably in single units, but with a little care in selecting the settings, they may be obtained in such fractional or multiple units that the reduction of the record into whole units will be exceedingly simple; we may, for instance, obtain records in which the wheel unit values may be .5, .2, .25, .01, 2, 4, 10 etc., square feet, square chains, square yards, etc., so that we have merely to multiply the number of wheel units by the value of one such unit, to obtain the real area of the plot represented by the map or plan.

There will naturally be but one setting of the tracer arm by means of which the wheel record will give at once the exact area of the piece of the map or plan round which the tracer has been carried. This setting will be found always to give 100 wheel units for one square inch, so that each wheel unit = .01 square inch. This is the equivalent of the setting of the Fixed Planimeter; but by varying the value of the wheel unit in accordance with the scale of the map or drawing, this same setting may be used for several different scales. It is clear therefore that the wheel unit will thus have two different values, namely:

- 1st. An *absolute value* x , that is, its ratio to the drawing itself, or to a scale of 1 = 1, and
- 2nd. A *comparative value* y , that is, its ratio to the *scale* of the drawing.

If the Planimeter registered linear measures, the ratio of its unit to the scale of the drawing would be

$$1 : D \times x = y$$

where D = the scale of the drawing, but as the instrument registers surface measures or areas only, this ratio is expressed by the equation

$$y = D^2 \times x \dots \dots \dots \text{Eq. 1}$$

from which

$$x = \frac{y}{D^2} \dots \dots \dots \text{Eq. 2}$$

We have stated that the best method of obtaining Settings is by means of a round trial disc inclosing an area of about 4 square inches, the exact figure being marked on the disc itself in square millimetres (1000 square $\frac{m}{m} = 1.55$ square inches.) If we now designate by W the num-

ber of wheel units registered by the tracer as it makes a complete circuit of the trial disc, we obtain the following:—

$$\text{Absolute value } x \text{ of one Wheel Unit} = \frac{\text{area of trial disc}}{W} \dots\dots \text{Eq. 3}$$

from which

$$W = \frac{\text{Area of trial disc}}{x} \dots\dots\dots \text{Eq. 4}$$

When W is known, the exact position of the movable arm is easily ascertained by trials, each result being noted for future reference and for facilitating the finding of other settings.

The following example will clearly show the method of using these formulæ, it being presumed that our trial disc has an area of 2580 square millimetres or 4 square inches.

*Example .—*What is the setting for a drawing made to a scale of 1 inch = 25 feet, with a value of 10 square feet assigned to each wheel unit?

$$\text{Here } D = 25, \quad D^2 = 625, \quad y = 10$$

$$\text{then } x = \frac{y}{D^2} = \frac{10}{625} = .016$$

$$\text{and } W = \frac{\text{area of disc}}{x} = \frac{4}{.016} = 250 \text{ Units,}$$

that is to say, the tracer arm should be so set that the wheel records 250 units, while the tracer makes one complete circuit of the trial disc. A little practice will enable the exact position of the tracer arm to be easily found, when the figures representing the same (say 11.6 divisions from zero, as shown by the vernier on the carriage,) are noted. This is then the setting for any drawing made to a scale of 1" = 25 feet, with a wheel unit of 10 square feet. If all instruments were absolutely alike in all their parts and proportions, these settings would serve for all, but as such cannot be the case, separate settings have to be obtained for each Planimeter.

In our Manual of the Polar Planimeter which accompanies each one of the instruments we are describing, a table is given of more than 50 different scales, with *suitable* values of the wheel unit y , the number of wheel units recorded for different discs, and approximative settings for the same, which will be found to simplify very considerably the obtaining of settings. The Manual can be obtained separately for 25 cents.

In our next article we shall show how suitable wheel units y may be obtained, as this point is one of considerable importance.

(To be continued.)



NEW BOOKS.

IRRIGATION CANALS AND OTHER IRRIGATION WORKS, AND THE FLOW OF WATER IN IRRIGATION CANALS, DITCHES, FLUMES, PIPES, SEWERS, CONDUITS, ETC., by P. J. Flynn, C.E.

These two volumes which are bound in one, will be received with pleasure by every Hydraulic Engineer, as the author in them expounds a complicated subject with an ability above the average and in a manner which calls forth the reader's constant attention. His style is clear, concise and fluent, the logical sequence of ideas is patent, and the language employed chosen and specially agreeable. Mr. Flynn is a happy and pleasing writer.

The printing of these volumes is excellent, good clear type on good paper, with broad margins. The illustrations which abound are very carefully worked out and clearly executed, and in this respect very considerably enhance the value of the work.

In the first volume the Author treats of the different systems of irrigation, comparing the American and Indian irrigation canals, with the latter of which he has had a very wide experience. He also fully discusses the construction of reservoirs, weirs, sluices, gates and other allied subjects.

The second volume takes up the question of the flow of water in open and closed channels. In no Engineering problems do "circumstances alter cases" so much perhaps, as in those relating to the flow of water, and here Mr. Flynn shows by comparative tables and tabulated formulæ the inefficiency of the older ones having constant coefficients, which are therefore of necessity applicable to certain and similar cases only, and consequently to but a small range of channels. He has selected as the most generally reliable one the formula known as Kutter's. The general objection to this formula (as well as to those of D'Arcy and Bazin) has been the tedious labor connected with its frequent application. To overcome this, Mr. Flynn has resolved the two formulæ $v = c \sqrt{R \times S}$ and $Q = ac \sqrt{R \times S}$ into their factors $c \sqrt{R}$, $\sqrt{S}$ and $ac \sqrt{R}$, and given their values for a great number of hydraulic mean depths, diameters, slopes and varying values of n , in a series of tables, the result of untold labors, by means of which the solution of the formulæ becomes an easy matter.

We cannot enter in this brief review into further details, but we feel safe in asserting that this work will take rank as the most thorough and exhaustive on the subject, and will be found of inestimable value to all those engaged in Hydraulic Engineering.

THE COMPASS.

A Monthly Journal published the first of every month, at 127 Fulton Street, New York City.

WILLIAM COX, - - - - -	Editor.
KEUFFEL & ESSER CO., - - - - -	Publishers.

SUBSCRIPTION \$1.00 per year, in advance, postage paid. Single Copies, 10 Cents each.
CORRESPONDENCE should be addressed to the Editor of THE COMPASS, 127 Fulton Street, New York City.

All such bearing upon the topics to which the Journal is devoted, will be thankfully received and acknowledged with pleasure.

CONTENTS.

	PAGE.
Ward's Engineer's Tape, - - - - -	161
Speedy Calculators, - - - - -	162
New Books, - - - - -	167
An Assortment of Handy Instruments for the Draughting Room, - - -	168
To find the Magnetic Pole, - - - - -	169
Round Writing, - - - - -	170
Engineering and Surveying Instruments, - - - - -	172
The Relation of Drawing to General Education. - - - - -	176

AN ASSORTMENT OF HANDY INSTRUMENTS FOR THE DRAUGHTING ROOM.

(Continued.)

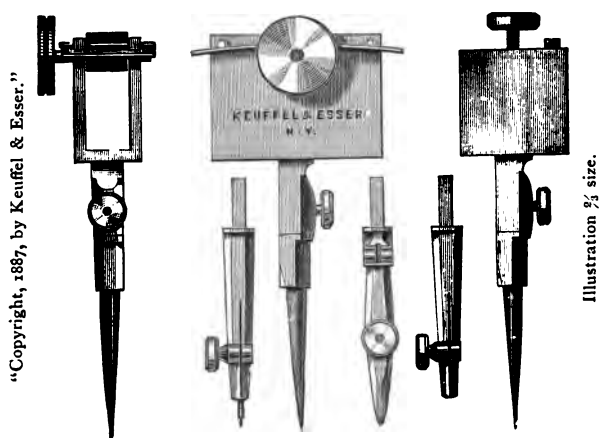


Fig. 1.

WHEN IT IS REQUIRED to measure or transfer considerable distances on a plan or drawing, or to describe arcs having long radii, recourse must be had to Beam Compasses, of which our illustrations show two of the best kinds. The special feature of No. 1 is a pinion in the top of the box, shown in the end view, which is pressed against the wooden bar by a spring, and can be turned round in either direction by a thumbscrew as shown. This pinion takes the place of a slow-motion screw and serves to adjust the points with precision. It does not in any way interfere with the box sliding freely along the bar.

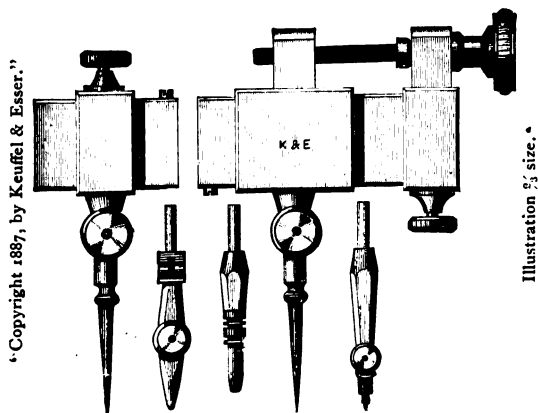


Fig. 2.

The Beam Compasses, Fig. 2, are probably the most perfect instrument of the kind; they are provided with a fine adjusting screw of 50 threads to the inch, for giving a very slow motion to the slide, so as to be able to adjust with nicety the points which are inserted in it, after clamping the box to the wooden bar. Both these instruments are much to be preferred to those in which the setting of the points is effected by means of an angular adjustment.

The quality of these instruments is of the best, both being of the well-known PARAGON make.



TO FIND THE MAGNETIC POLE.

SEVERAL MEMBERS of the American Geographical Society spoke at a meeting held in Chickering Hall, New York, on the 2nd of May, about the proposed expedition to find the north magnetic pole, which is about 1200 miles further south than the geographical pole. Gen. A. W. Greeley and Col. W. H. Gilder told how safely and comfortably the proposed expedition could be made. It is calculated that the magnetic pole is some-

where in the neighborhood of King William Land, possibly on water instead of land. English and other European explorers have been in that neighborhood. One of them got within a few miles of the exact point several years ago, and the magnetic needle pointed almost vertically. Its angle with the horizontal was $89^{\circ} 59'$. It is believed that the magnetic pole, which moves around a little, has a regular period that can be determined. It will be of advantage to navigators and surveyors to be able to allow for the variation at any time.

Col. Gilder, who accompanied Lieut. Schwatka on his expedition, has offered to take charge of the proposed trip to find the magnetic pole, and make a general survey of the surroundings. It is believed that there will be no difficulty in raising the necessary \$25,000. It is hoped that the U. S. Coast and Geodetic Survey will put the necessary instruments at the disposal of the expedition.—*N. Y. Sun.*

Round Writing.

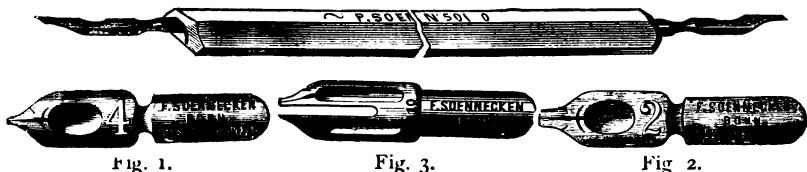


Fig. 1.

Fig. 3.

Fig. 2.

THE NEATNESS AND clearness of the lettering of titles of maps, plans, etc., as also the names of cities, rivers, details of construction of houses, machinery, etc., add very much to the appearance of such maps, plans or drawings. It is generally admitted that the simplest letters are the most effective, and that elaborate printing is an evidence of bad taste, and a waste of time.

It is a growing custom, and one which needs encouraging, to replace the old Roman and Italic letters by those of the new system of ROUND WRITING, so called because of its predominant form. It unites a distinctness, beauty and ease of execution, to which no other system can lay claim, and is chiefly to be preferred to all other kinds of lettering, because it is not, like them, more or less drawn, but is easily written.

In Round Writing the letters are developed in accordance with a standard rule, from certain plain rudimentary forms, that exhibit among themselves a peculiar harmony of dimensions. As compared with the

characters of current writing, and owing to the artistic form of the letters, Round Writing presents not only the advantage of greater precision, but also that of being easier of execution after a little practice, as it is done without pressure being applied to the pen, the thick strokes depending entirely upon the width of the nib selected, which causes them to be absolutely uniform.

To attain proficiency, three things should be taken into consideration:—

1st, that Round Writing is based upon a full acquaintance with, and due appreciation of the true character of the formation of the letters;

2nd, that there is a special and uniform way of holding the pen, which is indispensable to easy writing; and

3rd, that special broad-nibbed pens should be used, the omitting which makes it difficult, even for professional calligraphists, to imitate the writing, and impossible to acquire any degree of fluency in the art.

A METHODICAL TEXT BOOK has been prepared, which gives full directions for holding the pen, as well as a graduated series of exercises in writing, both of which are necessary to acquire proficiency. By following these directions strictly and consistently, proficiency and ease of execution, with elegance of style, will be quickly acquired, and then, as Professor J. B. Johnson says in his well known work on *The Theory and Practice of Surveying*, the lettering “looks well, when well done, and requires but a small fraction of the time required to make the ordinary letters. For working drawings and field maps it is specially adapted.”

The pens used in Round Writing are either single pointed, Figs. 1 and 2, or double pointed, as Fig. 3, so that the character of the letters (not their form) may be more or less varied if it is desired to make them somewhat ornamental.

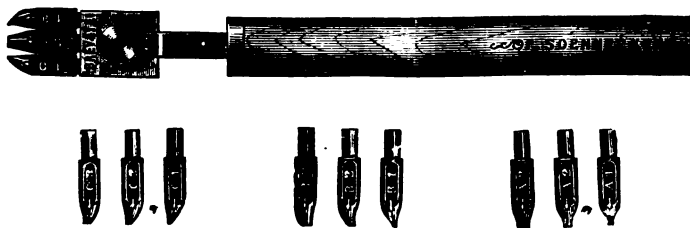


Fig. 4.

For large titles, a special Round Writing Instrument may be advantageously employed. Two or three pens are inserted in it side by side, as seen in Fig. 4, so that two or three strokes may be produced with one operation. The nibs of these pens (9 in number) vary, so that they allow of 144 different double, and 504 different triple lines being written with

them, by merely changing or interchanging the pens in the different places in the holder.

Musica

The above specimen is a reduction to one-half the size of the original, as executed with the Round Writing Instrument.

ENGINEERING AND SURVEYING INSTRUMENTS.

(Continued.)

THE TRANSIT.

GRADIENTER TABLE. II.*

* "Copyright 1892, by William Cox, New York."

Divisions.		Angle of Elevation.			Divisions.		Angle of Elevation.			Divisions.		Angle of Elevation.		
Index	Screw	°	'	"	Index	Screw	°	'	"	Index	Screw	°	'	"
	1	0	00	20.6		21	7	13.1			41	14	05.7	
	2	0	01.2			22	7	33.8			42	14	26.3	
	3	1	01.9			23	7	54.4			43	14	46.9	
	4	1	22.5			24	8	15.0			44	15	07.6	
	5	1	43.1			25	8	35.6			45	15	28.2	
	6	2	03.8			26	8	56.3			46	15	48.8	
	7	2	24.4			27	9	16.9			47	16	09.4	
	8	2	45.0			28	9	37.5			48	16	30.0	
	9	3	05.6			29	9	58.2			49	16	50.7	
	10	3	26.3			30	10	18.8			50	17	11.3	
	11	3	46.9			31	10	39.4			51	17	31.9	
	12	4	07.5			32	11	00.0			52	17	52.6	
	13	4	28.1			33	11	20.7			53	18	13.2	
	14	4	48.8			34	11	41.3			54	18	33.8	
	15	5	09.4			35	12	01.9			55	18	54.4	
	16	5	30.0			36	12	22.5			56	19	15.1	
	17	5	50.6			37	12	43.2			57	19	35.7	
	18	6	11.3			38	13	03.8			58	19	56.3	
	19	6	31.9			39	13	24.4			59	20	17.0	
	20	6	52.5			40	13	45.0			60	20	37.6	

Divisions.		Angle of Elevation.		Divisions.		Angle of Elevation.		Divisions.		Angle of Elevation.				
Index.	Screw	°	'	''	Index.	Screw	°	'	''	Index.	Screw	°	'	''
	61	20	58.2			50	51	33.8			90	3	22	35.6
	62	21	18.8			60	55	00.0		6	00	3	26	01.2
	63	21	39.5			70	58	26.2		10	3	29	26.7	
	64	22	00.1			80	1 01	52.4		20	3	32	52.2	
	65	22	20.7			90	1 05	18.6		30	3	36	17.7	
	66	22	41.3		2	00	1 08	44.7		40	3	39	43.1	
	67	23	02.0			10	1 12	10.9		50	3	43	08.5	
	68	23	22.6			20	1 15	37.1		60	3	46	33.9	
	69	23	43.2			30	1 19	03.3		70	3	49	59.2	
	70	24	03.9			40	1 22	29.5		80	3	53	24.6	
	71	24	24.5			50	1 22	55.7		90	3	56	49.9	
	72	24	45.1			60	1 29	21.8		7	00	4	00	15.2
	73	25	05.7			70	1 32	47.9		10	4	03	40.4	
	74	25	26.4			80	1 36	14.0		20	4	07	05.6	
	75	25	47.0			90	1 39	40.1		30	4	10	30.8	
	76	26	07.6		3	00	1 43	06.2		40	4	13	56.0	
	77	26	28.3			10	1 46	32.3		50	4	17	21.1	
	78	26	48.9			20	1 49	58.3		60	4	20	46.1	
	79	27	09.5			30	1 53	24.3		70	4	24	11.2	
	80	27	30.1			40	1 56	50.4		80	4	27	36.3	
	81	27	50.8			50	2 00	16.4		90	4	31	01.2	
	82	28	11.4			60	2 03	42.4		8	00	4	34	26.2
	83	28	32.0			70	2 07	08.4		10	4	37	51.1	
	84	28	52.7			80	2 10	34.4		20	4	41	16.0	
	85	29	13.3			90	2 14	00.4		30	4	44	40.9	
	86	29	33.9		4	00	2 17	26.3		40	4	48	05.7	
	87	29	54.5			10	2 20	52.2		50	4	51	30.5	
	88	30	15.2			20	2 24	18.1		60	4	54	55.3	
	89	30	35.8			30	2 27	44.0		70	4	58	20.1	
	90	30	56.4			40	2 31	09.9		80	5	01	44.8	
	91	31	17.0			50	2 34	35.8		90	5	05	09.4	
	92	31	37.7			60	2 38	01.6		9	00	5	08	34.0
	93	31	58.3			70	2 41	27.4		10	5	11	58.6	
	94	32	18.9			80	2 44	53.2		20	5	15	23.1	
	95	32	39.6			90	2 48	19.0		30	5	18	47.7	
	96	33	00.2		5	00	2 51	44.8		40	5	22	12.2	
	97	33	20.8			10	2 55	10.5		50	5	25	36.6	
	98	33	41.4			20	2 58	36.2		60	5	29	01.0	
	99	34	02.1			30	3 02	01.9		70	5	32	25.4	
I	00	34	22.7			40	3 05	27.6		80	5	35	49.7	
	10	37	48.9			50	3 08	53.3		90	5	39	13.9	
	20	41	15.1			60	3 12	18.9		10	00	5	42	38.2
	30	44	41.4			70	3 15	44.4						
	40	48	07.6			80	3 19	10.0						

The preceding table will be found very useful for ascertaining the value of small angles set off with the transit, and also for running grade lines.

Example.—The transit being leveled, the gradienter screw set to zero in the *middle* of the index, and the telescope raised through 4.40 divisions of the screw-head, what is the angle set off?

On looking at the table under 4 divisions of the index and 40 of the screw, we find the angle $2^{\circ} 31' 09''.9$.

Example.—What is the angle corresponding to a grade of $3\frac{1}{4}$ per cent. which has been run with a transit with gradienter attachment?

From the table we have for a grade of 3. 3 per cent., or

$$\begin{array}{rcl} 3.30 \text{ divisions of the gradienter} & = & 1^{\circ} 53' 24''.3 \\ 3 \ 20 \quad \quad \quad \quad \quad \quad \quad & = & 1 \ 49 \ 58. \ 3 \end{array}$$

$$\text{Difference for 10 divisions} = 0 \ 03 \ 26. \ 0$$

$$\begin{array}{rcl} \text{gives " 5 " } & = & 0 \ 01 \ 43. \ 0 \\ \text{and " 3.20 " } & = & 1 \ 49 \ 58. \ 3 \end{array}$$

$$\text{Angle of Elevation " 3.25 " } = 1 \ 51 \ 41. \ 3$$

We have stated that the gradienter should be so used that the measurements may be as far as possible distributed equally on each side of the index zero. We will take the first example and show the different results obtained by other methods of procedure.

1st. If we set the gradienter screw to 2.20 divisions on one side of zero, and turn it round to 2.20 divisions on the other side of zero, we shall then have

$$\text{Angle of Elevation for 2.20 divisions} = 1^{\circ} 15' 37''.1$$

giving consequently for twice 2.20, or

$$\text{Angle of Elevation for 4.40 divisions} = 2^{\circ} 31' 14''.2$$

2nd. If the gradienter screw be now set to the extreme end of the index, and 4.40 divisions be turned off towards zero, we shall have

$$\text{Angular Elevation for 5.00 divisions} = 2^{\circ} 51' 44''.8$$

$$\text{less " 0.60 " } = 0 \ 20 \ 37. \ 6$$

$$\text{leaves " 4.40 " } = 2^{\circ} 31' 07''.2$$

3rd. If we now take the value of 4.40 divisions from the ordinary tables which assume the angular value of the divisions to be equal, we should have

Value of 10 divisions = $0^{\circ} 3' 26.''26$

“ “ 40 “ = $0 13 45. 05$

“ “ 4.00 “ = $2 17 30. 40$

Value of 4.40 divisions = $2^{\circ} 31' 15.''44$

In these four different methods of working and calculating, we have supposed the gradienter screw to be each time turned through 4.40 divisions, and as the resulting angles of elevation are so different, it is evident that the intersection of the cross-hairs will not in each case fall exactly upon the same point of the rod. As the *equi-angular value* of the divisions of the gradienter is the main principle underlying the use of this attachment for measuring distances and heights, it is clear that that method of procedure which gives the most similar results is the one to be preferred, and this will be seen to be the one in which the gradienter divisions are distributed as nearly as possible in equal portions on each side of the index zero. In the previous example, the difference between the tangential angle of 4.40 divisions and the circumferential angle, is only $1.''24$, which may be said to be inappreciable. It is however sufficient to show that the equation

$$\tan \beta = \frac{n}{100} \text{ (see demonstration, page 143.)}$$

is not absolutely correct. If, however, the measurements be taken from the end of the index, or from the zero, the error will be greater, namely $8.''24$ and $5.''54$ respectively.

If these simple precautions be observed, the gradienter will be found exceedingly valuable, and for Railway and general Engineering work should invariably be attached to the transit.

In our next we shall complete these tables by giving one for setting off small angles by its means.

(To be continued.)



THE FOLLOWING METHOD of making paper transparent for copying drawings is adopted by the Austrian hydrographic bureau. The sheet of paper being placed over the drawing to be copied, it is lightly rubbed with a ball of cotton saturated with pure benzine. The tracing can then be readily made, owing to the transparency produced, and the benzine, on evaporating, leaves the paper opaque as before, and perfectly odorless. To secure satisfactory results, however, absolutely pure benzine must be used.—*Manufacturers' Gazette*.

THE RELATION OF DRAWING TO GENERAL EDUCATION.*

IT IS A FUNDAMENTAL principle in education that the school should seek to harmoniously develop each one of the pupil's intellectual faculties. A well-trained eye, a well-developed sense and appreciation of form and color, will always be found of great value in after life. . . . It is probably no exaggeration to say that the greater part of the educated classes walks about with open eyes, but without really seeing. Seeing is an art which must be acquired and practised. . . . Two prejudices will be found to exist, the one being the idea that drawing is nothing more than a mechanical acquirement, and the other the impression that they only, who have a natural talent for it, can attain any degree of proficiency in the art. We are not, it will readily be conceived, alluding here to the creative genius in art, which is the highest aim of drawing, but merely to the making of drawings which shall represent existing and visible objects. Can it be said then, in this sense, that drawing is merely the outcome of manual dexterity, or is it necessary that some higher sense be exercised? We believe that such representations or drawings of existing objects cannot be said to be the result of mere manual dexterity because they are produced by the hand. It is true that the hand is the member which performs the practical execution, but more, much more, is needed. We maintain that a searching intellect, a finely discriminating and sensitive soul are necessary in order that the characteristics of what the eye sees, may be grasped and reproduced by the hand with creative power. This is especially true in the case of drawing from the living model or from nature, that is, reproducing solid objects on a flat surface. It may be said, to use a modern phrase, that this is a sort of gymnastics for the mind, a determining of the different relations of position, size and apparent size (called fore-shortening); a mental measuring, analysing and re-arranging to make a harmonious whole. Drawing from nature is therefore in reality a translation of solid objects to a plane surface, and what the hand has to execute must be first thoroughly grasped by the mind, and have assumed definite shape in the draughtsman's brain. . . . It is also, as we have said, asserted by some that a peculiar natural talent is required to learn drawing. It is not however, a question of talent, nor is it the province of the school to educate artists in the highest sense of the term. This fallacy is probably the result of confusing the gift of independent and original production with that tendency to imitate, which is natural to every person, and with that sense of shape which is inherent in us all, and which can be very materially developed by systematic training.

*Extracts from a very interesting paper read before the Industrial School of Bavaria, by Prof. C. Th. Pohlig.



"COPYRIGHT, 1891, BY WILLIAM COX, NEW YORK."

**A Monthly Journal for Engineers, Surveyors, Architects, Draughtsmen
and Students.**

Vol. I.

JULY, 1, 1892.

No. 12.

*SERIES OF NUMBERS AND THEIR APPLICATION
TO SCIENTIFIC PURPOSES.*

SOME OF OUR READERS doubtless use at times an ordinary carpenter's 2 foot rule, having in one of its legs a narrow brass slide, with four graduated scales, marked *A*, *B*, *C* and *D*, and will have remarked that the three former ones are the same as those of the ordinary Slide Rule, whereas the fourth scale *D* begins with 4 and runs up to 40.

This rule, called Coggeshall's or the Carpenter's Sliding Rule, is mostly used for taking the dimensions and ascertaining the contents of timber. The scales *A* and *B* are double ones as on the ordinary Slide Rule which we have already described, and are used for the purposes of ordinary calculations. The scale *C* is the same as the scales *A* and *B* and is used in conjunction with scale *D*, which is a single one and is graduated as scale *D* of the Mannheim, but instead of reaching from 1 to 10, it is graduated and numbered from 4 to 40, the graduations being subdivided into eighths and quarters instead of decimally. This scale is called the *Girt Line*, because in calculating the solid contents the quarter girt dimensions are taken upon it.

It is not necessary to describe here the methods of using the Carpenter's Sliding Rule for the effecting of ordinary calculations, as it will be at once seen that they are the same as those used in the case of the ordinary Slide Rule. We shall merely show by a few examples how it is generally employed for ascertaining the cubical contents of squared or round timbers.

1st. Find the contents of a beam 14 inches broad, 12 inches thick and 15 feet long.

$$\begin{array}{l} C \parallel \text{Set Length in Feet} \mid \text{Find Cubic Feet.} \\ D \parallel \text{To G. P. 12} \mid \text{Above quarter Girt} \end{array}$$

$$\begin{array}{l} C \parallel \text{Set 15 Feet} \parallel \text{Find 17.6 c. feet} \\ D \parallel \text{To 12} \parallel \text{Above } \frac{14 + 12}{2} \end{array}$$

This amount is only approximate and is subject to a subtractive correction proportionate to the difference between the thickness and the breadth, that is the difference between $\left(\frac{14 + 12}{2}\right)^2$ and 14×12 , or 169 and 168. When the breadth is much greater than the thickness, this error is proportionately greater, thus if the breadth be 14 inches and the thickness 8 inches, we have $\left(\frac{14 + 8}{2}\right)^2 = 11^2 = 121$ and $14 \times 8 = 112$, showing an excess of $9\frac{1}{2}$ per cent.

2nd. Find the contents of a round piece of timber 28 feet long with a quarter girt of 10 inches.

$$\begin{array}{l} C \parallel \text{Set Length in Feet} \mid \text{Find Cubic Feet.} \\ D \parallel \text{To G. P. } 10\frac{5}{8} \mid \text{Above quarter Girt} \end{array}$$

$$\begin{array}{l} C \parallel \text{Set 28 Feet} \mid \text{Find 24.75 c. feet} \\ D \parallel \text{To } 10\frac{5}{8} \mid \text{Above 10 inches} \end{array}$$

In this case, as in that of *square* beams, the result is correct.

3rd. Find the contents of a square piece of tapering timber 24 feet long, whose quarter girt at one end is 18 inches and at the other end 10 inches.

$$\begin{array}{l} C \parallel \text{Set Length in Feet} \mid \text{Find Cubic Feet} \\ D \parallel \text{To G. P. 12} \mid \text{Above half sum of quarter Girts.} \end{array}$$

Again

$$\begin{array}{l} C \parallel \text{Set one third Length} \mid \text{Find Cubic Feet} \\ D \parallel \text{To G. P. 12} \mid \text{Above half difference of quarter Girts.} \end{array}$$

The sum of the two amounts thus obtained will be the contents of the piece of timber, thus

$$\begin{array}{r|l|l} C & \parallel & \text{Set 24 Feet} \mid \text{Find 32.66 C. Feet} \\ D & \parallel & \text{To 12} \mid \text{Above 14} \end{array}$$

Again

$$\begin{array}{r|l|l} C & \parallel & \text{Set 8 Feet} \mid \text{Find 0.88 C. Feet} \\ D & \parallel & \text{To 12} \mid \text{Above 4} \end{array}$$

then $32.66 + 0.88 = 33.54 = \text{Contents in Cubic Feet.}$

The contents of a tapering round piece of timber are obtained in the same way by using G. P. $10\frac{1}{2}$ instead of 12.

If in squared tapering timber, the breadth is much greater than the thickness, a correction will have to be applied as in Example 1. A table of corrections per cent can be easily made.

We much prefer working out these various problems on the Mannheim Slide Rule, as follows for the first example.

$$\begin{array}{r|l|l|l|l} C & \parallel & \text{Set 1} & \mid R \text{ to thickness} \mid 144 \text{ to } R & \mid \text{Below length in feet} \\ D & \parallel & \text{To breadth in} & \mid & \mid \text{Find Cubic Feet} \\ & & \text{inches} & & \end{array}$$

In this way no correction is required and the runner very much facilitates the computations. We have also at once the contents for any length of beam of same breadth and thickness.



STEEL TAPE FOR MEASURING DIAMETERS AND CIRCUMFERENCES.

IT MAY INTEREST some of our readers to know that there is on the market a steel tape of the well known EXCELSIOR make, by means of which the diameter of a cylinder or other circular object may be at once ascertained by simply measuring its circumference. It consists of an *ordinary* steel pocket tape, 12 feet long, in German silver case, with spring and stop, marked on the one side in inches and sixteenths of an inch. On the reverse side spaces equal to 3.1416 inches each are marked off and numbered 0, 1, 2, etc., the first one being subdivided into 64 equal parts. By passing this tape round any large cylinder, the circumference is at once read off on one side of the tape, and the diameter on the other side. There must be many cases in which such an instrument would be found useful and certainly handier than a pair of large calipers.

ENGINEERING AND SURVEYING INSTRUMENTS.

(Continued.)

THE TRANSIT.

GRADIENTER TABLE. III.*

* "Copyright 1892, by William Cox, New York."

Angle of Elevation.			Divisions.		Angle of Elevation.			Divisions.		Angle of Elevation.			Divisions.	
°	'	"	Index.	Screw	°	'	Index.	Screw	°	'	Index.	Screw	Index.	Screw
0	0	10		00.5	30			87.3	1	4	1	86.2		
		20		01.0	31			90.2	1	5	1	89.1		
		30		01.5	32			93.1	1	6	1	92.0		
		40		01.9	33			96.0	1	7	1	94.9		
		50		02.4	34			98.9	1	8	1	97.8		
01				02.9	35	1	01.8	1	9	2	00.7			
2				05.8	36	1	04.7	1	10	2	03.6			
3				08.7	37	1	07.6	1	11	2	06.6			
4				11.6	38	1	10.5	1	12	2	09.5			
5				14.5	39	1	13.4	1	13	2	12.4			
6				17.5	40	1	16.4	1	14	2	15.3			
7				20.4	41	1	19.3	1	15	2	18.2			
8				23.3	42	1	22.2	1	16	2	21.1			
9				26.2	43	1	25.1	1	17	2	24.0			
10				29.1	44	1	28.0	1	18	2	26.9			
11				32.0	45	1	30.9	1	19	2	29.8			
12				34.9	46	1	33.8	1	20	2	32.7			
13				37.8	47	1	36.7	1	21	2	35.7			
14				40.7	48	1	39.6	1	22	2	38.6			
15				43.6	49	1	42.5	1	23	2	41.5			
16				46.5	50	1	45.4	1	24	2	44.4			
17				49.5	51	1	48.3	1	25	2	47.3			
18				52.4	52	1	51.3	1	26	2	50.2			
19				55.3	53	1	54.2	1	27	2	53.1			
20				58.2	54	1	57.1	1	28	2	56.0			
21				61.1	55	1	60.0	1	29	2	58.9			
22				64.0	56	1	62.9	1	30	2	61.8			
23				66.9	57	1	65.8	1	31	2	64.8			
24				69.8	58	1	68.7	1	32	2	67.7			
25				72.7	59	1	71.6	1	33	2	70.6			
26				75.6	1 00	1	74.5	1	34	2	73.5			
27				78.5	1 1	1	77.5	1	35	2	76.4			
28				81.4	1 2	1	80.4	1	36	2	79.3			
29				84.4	1 3	1	83.3	1	37	2	82.2			

Angle of Elevation. ° ' "	Divisions.		Angle of Elevation. ° ' "	Divisions.		Angle of Elevation. ° ' "	Divisions.	
	Index.	Screw		Index.	Screw		Index.	Screw
1 38	2	85.1	2 24	4	19.1	3 10	5	53.2
1 39	2	88.0	2 25	4	22.0	3 11	5	56.2
1 40	2	91.0	2 26	4	24.9	3 12	5	59.1
1 41	2	93.9	2 27	4	27.9	3 13	5	62.0
1 42	2	96.8	2 28	4	30.8	3 14	5	64.9
1 43	2	99.7	2 29	4	33.7	3 15	5	67.8
1 44	3	02.6	2 30	4	36.6	3 16	5	70.7
1 45	3	05.5	2 31	4	39.5	3 17	5	73.7
1 46	3	08.4	2 32	4	42.4	3 18	5	76.6
1 47	3	11.3	2 33	4	45.3	3 19	5	79.5
1 48	3	14.3	2 34	4	48.3	3 20	5	82.4
1 49	3	17.2	2 35	4	51.2	3 21	5	85.3
1 50	3	20.1	2 36	4	54.1	3 22	5	88.3
1 51	3	23.0	2 37	4	57.0	3 23	5	91.2
1 52	3	25.9	2 38	4	59.9	3 24	5	94.1
1 53	3	28.8	2 39	4	62.8	3 25	5	97.0
1 54	3	31.7	2 40	4	65.7	3 26	5	99.9
1 55	3	34.6	2 41	4	68.7	3 27	6	02.9
1 56	3	37.6	2 42	4	71.6	3 28	6	05.8
1 57	3	40.5	2 43	4	74.5	3 29	6	08.7
1 58	3	43.4	2 44	4	77.4	3 30	6	11.6
1 59	3	46.3	2 45	4	80.3	3 31	6	14.5
2 00	3	49.2	2 46	4	83.2	3 32	6	17.5
2 01	3	52.1	2 47	4	86.2	3 33	6	20.4
2 02	3	55.0	2 48	4	89.1	3 34	6	23.3
2 03	3	57.9	2 49	4	92.0	3 35	6	26.2
2 04	3	60.8	2 50	4	94.9	3 36	6	29.1
2 05	3	63.8	2 51	4	97.8	3 37	6	32.1
2 06	2	66.7	2 52	5	00.7	3 38	6	35.0
2 07	3	69.6	2 53	5	03.7	3 39	6	37.9
2 08	3	72.5	2 54	5	06.6	3 40	6	40.8
2 09	3	75.4	2 55	5	09.5	3 41	6	43.7
2 10	3	78.3	2 56	5	12.4	3 42	6	46.7
2 11	3	81.2	2 57	5	15.3	3 43	6	49.6
2 12	3	84.2	2 58	5	18.2	3 44	6	52.5
2 13	3	87.1	2 59	5	21.2	3 45	6	55.4
2 14	3	90.0	3 00	5	24.1	3 46	6	58.3
2 15	3	92.9	3 01	5	27.0	3 47	6	61.3
2 16	3	95.8	3 02	5	29.9	3 48	6	64.2
2 17	3	98.7	3 03	5	32.8	3 49	6	67.1
2 18	4	01.6	3 04	5	35.7	3 50	6	70.0
2 19	4	04.6	3 05	5	38.7	3 51	6	73.0
2 20	4	07.5	3 06	5	41.6	3 52	6	75.9
2 21	4	10.4	3 07	5	44.5	3 53	6	78.8
2 22	4	13.3	3 08	5	47.4	3 54	6	81.7
2 23	4	16.2	3 09	5	50.3	3 55	6	84.6

Angle of Elevation. ° ' "	Divisions.		Angle of Elevation. ° ' "	Divisions.		Angle of Elevation. ° ' "	Divisions.	
	Index.	Screw		Index.	Screw		Index.	Screw
3 56	6	87.6	4 18	7	51.9	4 40	8	16.3
3 57	6	90.5	4 19	7	54.8	4 41	8	19.2
3 58	6	93.4	4 20	7	57.7	4 42	8	22.1
3 59	6	96.3	4 21	7	60.7	4 43	8	25.1
4 00	6	99.3	4 22	7	63.6	4 44	8	28.0
4 01	7	02.2	4 23	7	66.5	4 45	8	30.9
4 02	7	05.1	4 24	7	69.4	4 46	8	33.9
4 03	7	08.0	4 25	7	72.4	4 47	8	36.8
4 04	7	11.0	4 26	7	75.3	4 48	8	39.7
4 05	7	13.9	4 27	7	78.2	4 49	8	42.6
4 06	7	16.8	4 28	7	81.2	4 50	8	45.6
4 07	7	19.7	4 29	7	84.1	4 51	8	48.5
4 08	7	22.6	4 30	7	87.0	4 52	8	51.4
4 09	7	25.6	4 31	7	89.9	4 53	8	54.4
4 10	7	28.5	4 32	7	92.9	4 54	8	57.3
4 11	7	31.4	4 33	7	95.8	4 55	8	60.2
4 12	7	34.3	4 34	7	98.7	4 56	8	63.2
4 13	7	37.3	4 35	8	01.6	4 57	8	66.1
4 14	7	40.2	4 36	8	04.6	4 58	8	69.0
4 15	7	43.1	4 37	8	07.5	4 59	8	71.9
4 16	7	46.0	4 38	8	10.4	5 00	8	74.9
4 17	7	49.0	4 39	8	13.4			

The preceding table will be found useful for setting off small vertical angles of elevation or depression. The divisions of the gradienter screw are obtained from the exact tangents of the angles, and in the case of the larger angles, if extreme accuracy is desired, the same precautions as already stated should be observed.

It may not be amiss to state here that Tables II and III may also be used for determining grades with the vertical limb or arc of the Transit, as they give at once the rise per cent corresponding to any angle, as well as the angle corresponding to a slope of so much per cent.; thus in Table III, we find that a slope of 2.24 per cent. is equivalent to an angle of $1^{\circ} 17'$, and from Table II that an angle of $33'$ is equivalent to a rise of $\frac{9.6}{100}$ per cent.

We close this portion of our subject by quoting a few remarks of Mr. F. Hodgman, Secretary of the Michigan Engineering Society and author of *A Manual of Land Surveying*, as given in that Society's Annual for 1891. He says:

"In my opinion its greatest value is for use on railroad location in an open country, where it is a most valuable assistant in selecting the position

of the line to be located. An adjustment of the instrument and a glance at the gradienter tells the locating engineer in feet per hundred just what kind of slope he has to contend with, and if it be in a mountainous region where a certain grade line has to be fitted to the ground, it tells him at a glance, without waiting for the leveler, where to find the ground to fit his grade line. I have found in work of this kind that the gradienter saved nearly, if not quite, half the time of the party; in other words, that I could get nearly twice as much accomplished with it as I could without it, because of the saving in preliminary work by being able to locate the line in the right place the first time trying."

Having now brought to a close our cursory remarks upon the Transit, it gives us pleasure to add that most of the improvements described are due to the genius of Mr. John Paoli, the head of the department of Instruments of Precision and Fine Mechanics at Messrs. Keuffel & Esser Co's works at Hoboken, N. J. Mr. Paoli is an Italian, who served his time at the well known Galilei Establishment at Florence, Italy. He then came to this country and eventually entered the service of his present employers. Beginning at the foot of the ladder, he soon showed the metal of which he was made, and succeeded, by perseverance and steady application, combined with clear mechanical insight and ability, to command the position which he now holds.

INFLUENCE OF THE MOON ON THE BAROMETER.

MR. BÖRNSTEIN, in a recent article in the *Meteorologische Zeitschrift*, refers to the question as to whether there exists any relation between the pressure of the atmosphere and the altitude of the moon. This study is based upon observations made at four different stations in Germany and Austria, and does not take into account the phases of the moon, or her distance from the earth, but considers merely the lunar day. The results obtained are:—1st, that the variations of pressure do not indicate any atmospheric tides, and 2nd, that at three of the stations, the pressure shows but one oscillation during the lunar day. At Berlin and at Hamburg the maximum takes place a little before the moon sets, and at Vienna, at the moment of least culmination, whereas the minimum takes place, at all the stations, at the moment of the moon's rising.

THE COMPASS.

A Monthly Journal published the first of every month, at 127 Fulton Street, New York City.

WILLIAM COX, - - - - -	Editor.
KEUFFEL & ESSER CO., - - - - -	Publishers.

SUBSCRIPTION \$1.00 per year, in advance, postage paid. Single Copies, 10 Cents each.
CORRESPONDENCE should be addressed to the Editor of THE COMPASS, 127 Fulton Street, New York City.

All such bearing upon the topics to which the Journal is devoted, will be thankfully received and acknowledged with pleasure.

CONTENTS.

	PAGE.
Series of Numbers and their Application to Scientific Purposes, - - - - -	177
Steel Tape for Measuring Diameters and Circumferences - - - - -	179
Engineering and Surveying Instruments, - - - - -	180
Influence of the Moon on the Barometer, - - - - -	183
Speedy Calculators, - - - - -	184
Both's Section-Liner and Scale-Divider, - - - - -	189

SPEEDY CALCULATORS.

(*Continued.*)

THE POLAR PLANIMETER.

WE HAVE ALREADY seen how to obtain the setting of the Tracer Arm of the Planimeter for a drawing made to any given scale, and also how this setting depends upon the value assigned to a single Wheel Vernier Unit. It is necessary that these values should be selected in accordance with the scale of the drawing and the capacities of the instrument, otherwise we might exceed these latter by selecting a unit which would require the tracer arm to be either longer or shorter than it really is.

The revolutions of the wheel vary in proportion to the length of the tracer arm, being greatest when JT is shortest, and least when JT is longest, thus an instrument which we have just tried, gives the following results, the tracer in each case being taken round a trial disc of 4.17 square inches,

Tracer Arm Setting	o	Wheel Units	245
do	do 100	do	340
do	do 200	do	560
do	do 250	do	810

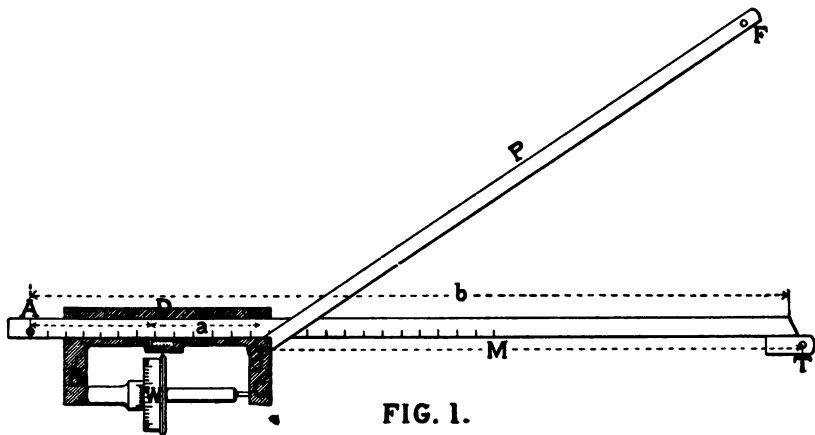
It is clear therefore that the number of units should come within the limits of 250 and 800, the latter being obtained when the tracer arm is but 2 inches long, and consequently only suitable for very small drawings.

A suitable value for the wheel unit y may be obtained from the equations given in our last.

$$\text{By Eq. 1} \dots\dots\dots y = D^2 \times x$$

$$\text{and by Eq. 4} \qquad W = \frac{\text{Area of trial disc}}{x}$$

$$\text{whence } y = \frac{D^2 \times \text{area of trial disc}}{W} \dots\dots\dots \text{Eq. 5}$$



We will now apply this equation to the following example:—Find a suitable value for the wheel unit for a drawing to a scale of 1 inch = 25 feet, with a trial disc of 4 square inches.

Here $D = 25$, and $D^2 = 625$, so that we have

$$y = \frac{625 \times 4}{W} = \frac{2500}{W}$$

The value of W must now be chosen, and it should be such that it will divide into 2500 without a remainder, and also that y (the quotient of $2500 \div W$) may be an easy number to multiply by, such as 1, 2, 5, .4, .2 etc. It must also be chosen so that y may come within the limits of 250 and 800, which are those of the instrument. If therefore we take in the present instance 250 to be the value of W we have

$$y = \frac{625 \times 4}{250} = 10 \text{ square feet}$$

which would be the value of a single wheel vernier unit for a drawing

made to a scale of 1 inch = 25 feet. Knowing now that the wheel should record 250 units during the passage of the tracer once round the trial disc, we find by repeated trials the exact setting of the tracer arm, say 11.6, which will give this result, and therefore take note of this setting for future use, thus:—

Scale of Drawing	Value of 1 Wheel Unit y .	Trial Disc Units	Setting
1 in = 25 feet.	10 square feet.	250	11.6

It will frequently happen that the same setting will serve for drawings made to different scales, by assigning different values to the wheel unit y .

$$\text{By Eq. 5, } y = \frac{D^2 \times \text{Area trial disc}}{W}$$

$$\text{whence } D^2 = \frac{y \times W}{\text{area trial disc}} \dots \dots \dots \text{Eq. 6.}$$

Here the value of W and the area of the trial disc are constant, while D^2 and y may be made to proportionately vary. Let us take for y different values such as 10 and 40, these being always such that in the solution of the equation, the square root of D^2 may be a whole number without any remainder. Applying equation 6 to our example, we have

$$D^2 = \frac{10 \times 250}{4} = 625, \text{ whence } D = 25$$

$$\text{and } D^2 = \frac{40 \times 250}{4} = 2500, \text{ " } D = 50;$$

in the latter case the scale of the drawing is 1 inch = 50 feet and the wheel unit 40 square feet, the setting being the same as in the former case.

If now with a drawing or plan made to this scale, we pass the tracer round a given plot, and the instrument registers 1587, this number being composed of 1 on the disc, 58 on the wheel, and 7 read off by means of the wheel vernier, then the real area of the surface of the plot represented by the drawing will be

$$W \times y = 1587 \times 40 = 63,480 \text{ square feet.}$$

The foregoing explanations have special reference to the case of drawings whose size permits of their perimeter being circumscribed by the tracer, with the fulcrum or pole placed *outside* the figure whose area is required. The case, however, frequently presents itself in which the size of the drawing necessitates the fulcrum being placed *within* the area of the drawing itself, so that as the tracer is made to go round the figure to be measured, it and the wheel describe a more or less regular circle round the fulcrum.

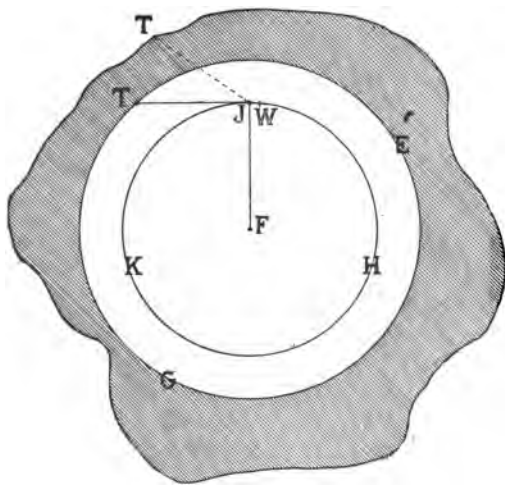
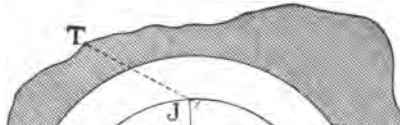


FIG. 2.

If the tracer arm JT , Fig. 2, were fixed at a right angle to an imaginary line FW , drawn from the fixed pole F to the flange of the wheel, it is evident that, as the tracer is drawn round, the wheel would not revolve at all, its axis remaining during the whole passage in the direct line of motion, or its flange moving the whole time perpendicularly to its plain. A circle EGT , called the datum or zero circle, would therefore be described by the tracer T , with a radius equal to the

distance FT , of which the wheel would give no record. Any divergence of the tracer however, from the line of this circle, caused by opening or closing more or less the arms, and consequently increasing or diminishing the angle TWF , would cause the wheel to revolve. This rotary motion of the wheel would be in a *forward* direction if the perimeter of the figure to be measured lay outside the circle EGT , and in a *backward* direction, if the perimeter lay within the circle EGT . The wheel thus registers *positive* or *negative* units according as the tracer goes beyond or enters within this circle EGT , whilst in the case of a combination of the two directions, as would occur with an irregular figure as shown in Fig. 3, the difference between the two is recorded, that is the difference between the external and the internal portions as shown by the two shaded parts in the figure.



The area of a figure measured with the Polar Planimeter is recorded by the wheel W , but in the case of large surfaces necessitating the placing of the fulcrum within the drawing, a certain *Constant*, representing the area inclosed by the datum circle, must be added to the wheel record, this constant naturally

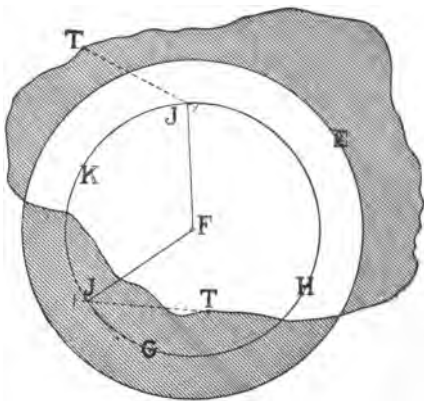


FIG. 3.

varying with each setting or with the length $J T$ of the tracer arm, and also with the value assigned to the wheel vernier unit.

The following is perhaps the simplest method of ascertaining these constants. Having "set" the arm as required for the given drawing scale, place the fulcrum in the centre of a large sheet of paper on the drawing board and attach thereto the ball joint; then with the arms opened out to their fullest extent, trace a complete circle, and note carefully the readings of the instrument, as also the diameter of the circle so traced, and calculate therefrom its exact area. From this area, reduced to units according to the scale of the drawing and the value of the wheel unit, deduct the reading of the Planimeter, and the difference will be the constant required, or the value in units of the datum circle.

Example:—Find the Constant for inside positions for drawings made to a scale of 1 inch = 10 feet, with a vernier unit of 1 square foot.

After properly setting the arm and describing a circle as stated, we find its diameter to be 19.98 inches, giving consequently an area of 313.52 square inches. For a scale of 1 inch = 10 feet, or 1 square inch = 100 square feet, with a wheel unit of 1 square foot, we have

$$\frac{313.52 \times 100}{1} = 31352 \text{ Units}$$

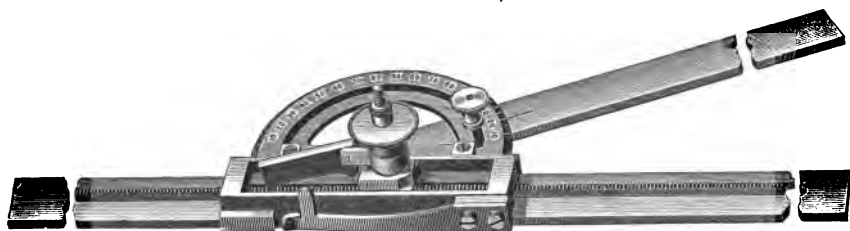
corresponding to the given area. If in describing the above circle, the instrument has registered 12160 units, we have $31352 - 12160 = 19192$ as the value of the constant for this setting and wheel unit, and this must always be added to the wheel record, in order to obtain the area of any plot, etc., whose extent necessitates the placing of the fulcrum within the area itself. Due care must be taken to note whether, as the tracer is carried round the perimeter of the plot, the wheel registers positive or negative units, or a combination of these, as would be the case in Fig. 3, as the result is naturally influenced by these conditions. If the final record be negative, then it must be deducted from the Constant in order to obtain the area of the plot.



INDIAN ENGINEERING, in a recent number, describes a novel method of making foundations in cases where the ground is damp. A hole is first bored, about $1\frac{1}{2}$ inches diameter and 10 to 12 feet deep, then charged with cartridges. These, when exploded, not only excavate a hole 3 feet in diameter, but drive the water out of the earth surrounding the hole to such a distance that it does not filter back for more than an hour, during which time the excavation is filled with quick setting concrete. By the time the moisture returns, the concrete is sufficiently hardened to resist the encroachments of the water, and a series of substantial foundations may be thus rapidly secured.

BOTH'S SECTION-LINER AND SCALE-DIVIDER.

PATENTED NOV. 20, 1888.



THIS SECTION-LINER and Scale-Divider is the easiest to manipulate, the most rapid and exact in execution, the finest in workmanship, and the most durable of any hitherto known. It consists of the following principal parts:—

1st. A *flat* or *rack-bar*, forming the base of the instrument, $14\frac{3}{4}$ inches long, having affixed to it centrally and longitudinally, a fine rack, 9 inches long, with 24 teeth to the inch.

2nd. A *carriage*, nicely fitted and made to slide on the rack-bar.

3rd. An upright steel *pin* fastened to the centre of the carriage. A collar with a *knob* slides up and down on this pin, the length of its course being regulated by means of an *adjusting nut*. A spiral spring pushes the collar upwards until it is arrested by the nut.

4th. A steel *pawl*, pivoted to the collar, with its other end engaged in the teeth of the rack, so that when the collar is pushed down by pressing the knob—the pawl being held by a tooth of the rack—the carriage is forced to advance along the rack-bar from 1 to 6 teeth at a time, according to the take-up to which the adjusting nut has been set.

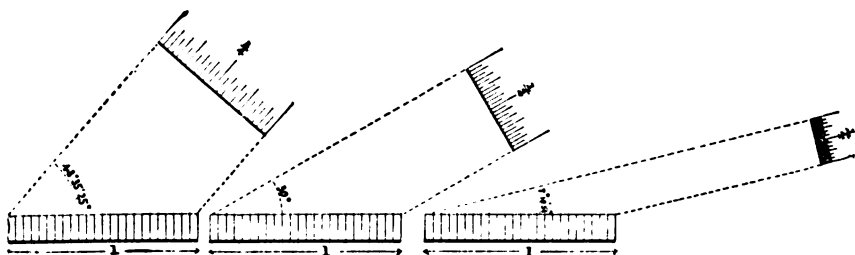
5th. A semi-circular *protractor*, attached to the carriage and graduated to degrees.

6th. A *ruler arm*, pivoted to the protractor, so that it may be placed at any angle to the rack-bar, and be firmly held there by a milled headed screw.

HOW TO USE THE INSTRUMENT.

It will be evident from the illustration, Fig. 1, that if the ruler arm is set at a right angle to the rack-bar (shown by setting the index on the arm to 90° of the protractor) it will move with each pressure of the knob a distance equal to the number of teeth for which the take-up has been adjusted, thus enabling lines $\frac{1}{24}$, $\frac{1}{12}$, $\frac{1}{6}$, $\frac{1}{4}$ or $\frac{1}{2}$ inches apart to be both accurately and rapidly drawn. It will also be clear that if the arm is set at an angle less than 90° , as shown in Fig. 2, that the space between the

lines will also be less, diminishing as the angle becomes more acute, and that we may consequently establish any desired ratio between the rack scale (24 to the inch) and the drawn scale as reduced by the ruler arm.



This ratio is the natural sine of the angle formed by the ruler arm and the rack-bar, thus:—Let it be required to draw a scale of 12 to the inch, then we have $\frac{12}{24} = .5$, which is the sine of 30° , or the angle to which the ruler arm must be set. It should be noted that when obtaining settings or angles, the two scales must always be reduced to the same denomination.

The following simple rule will be found easy of application, and to answer all cases:

Take 24 divisions of the drawn scale and 24 divisions of the rack scale, each reduced to the same common denomination; the quotient of the former divided by the latter will then be the sine of the angle to which the ruler arm must be set.

Example.:—Required the setting for an Engineer's scale of 800 parts to a foot.

Here 24 divisions of the drawn scale $= \frac{24}{800}$, and as the rack has 24

teeth per inch or 288 per foot, 24 divisions of the rack, $= \frac{24}{288} = \frac{1}{12}$.

Then $\frac{24}{800} \div \frac{1}{12} = \frac{24 \times 12}{800} = .36 = \text{sine of } 21^\circ 06'$, the angle required.

Example.:—Find the setting for a Surveyor's scale of 30 feet per inch.

Here 24 divisions of the drawn scale $= \frac{24}{30 \times 12}$, and 24 divisions of

the rack as before $= \frac{1}{12}$, so that we have $\frac{24}{30 \times 12} \div \frac{1}{12} = \frac{24 \times 12}{30 \times 12} = .8 = \text{sine of } 53^\circ 08' = \text{angle required.}$

Example.—What is the setting for an Architect's or Mechanical Draughtsman's scale of $\frac{3}{4}$ " = 1 foot, divided to twelfths or inches?

Here 1 division of the drawn scale = $\frac{3}{4 \times 12}$ inch = $\frac{3}{4 \times 12 \times 12}$ foot, and 24 divisions = $\frac{3 \times 24}{4 \times 12 \times 12}$; as 24 divisions of the rack as before = $\frac{1}{12}$, we have $\frac{3 \times 24 \times 12}{4 \times 12 \times 12} = 1.5$. Here it is evident that the angle is more than 90° , so we set the adjusting nut to allow the pawl to take up 2 teeth at a time, when 24 divisions of the rack will = $\frac{1}{8}$ foot, then we have $\frac{3 \times 24 \times 6}{4 \times 12 \times 12} = .75$
= sine of $48^\circ 35'$.

Example.—What is the setting for a Metric scale of 1 Met. = 1^m 50 graduated to millimetres and halves?

In this case 1^m 50 will have 3000 graduations, so that 1 Metre will have 2000 lines or graduations, which gives

$$\frac{304.79 \times 2000}{1000} = 609.59 \text{ lines per foot, whence we have } \frac{24 \times 12}{609.59} = .47245 = \text{sine of } 28^\circ 12'.$$

The following table gives settings or angles for producing the different scales in general use.

It needs no demonstration to show that this instrument is also peculiarly suitable for *Section-Lining*, as from 4 to 100 parallel straight lines per inch or more may be easily drawn with it, one simple pressure of the finger upon the knob being all that is required. Drawings so shaded will have their beauty much increased by the neatness and precision with which the shading is executed; great relief will also be afforded to the eyes and much valuable time saved.

The table gives at a glance the number of lines per inch obtained by various angular settings of the ruler arm and the pawl, from which a sample card may be easily prepared, thus facilitating the choice of a degree of shade and the prompt setting of the instrument.

The comfort and satisfaction attending the use of this instrument, the assurance of being able to do absolutely accurate work in less time than with any other, its easy adjustment for section-lining or for scales, its great scope, together with duration and neatness, make it without exception a superior instrument and a valuable and most useful addition to the outfit of every draughtsman who knows and appreciates the value of good tools.

LIST OF ANGLES OR SETTINGS FOR PRODUCING THE DIFFERENT SCALES IN
GENERAL USE.

ENGINEERS' SCALES: SCALES FOR DECIMAL PARTS OF A FOOT.

Scale.	Lines per Foot.	Lines per Inch.	Angle.	Setting of Pawl.
1' = 1000'	1000	83 $\frac{1}{2}$	16° 45'	1 Tooth.
1' = 900'	900	75	18° 40'	1 "
1' = 800'	800	66 $\frac{2}{3}$	21° 06'	1 "
1' = 700'	700	58 $\frac{1}{3}$	24° 18'	1 "
1' = 600'	600	50	28° 41'	1 "
1' = 500'	500	41 $\frac{2}{3}$	35° 10'	1 "
1' = 400'	400	33 $\frac{1}{3}$	46° 04'	1 "
1' = 300'	300	25	73° 45'	2 Teeth.
1' = 200'	200	16 $\frac{2}{3}$	46° 04'	2 "
1' = 100'	100	8 $\frac{1}{3}$	73° 45'	2 "

ARCHITECTS' AND MECHANICAL DRAUGHTSMEN'S SCALES.
DUODECIMAL OR INCH SCALES.

Scale.	Lines per Foot.	Lines per Inch.	Angle.	Setting of Pawl.	Graduates to
1" = 1'	1152	96	14° 29'	1 Tooth.	Inches.
1" = 1'	864	72	19° 28'	1 "	"
1" = 1'	576	48	30° 00'	1 "	"
1" = 1'	768	64	22° 01'	1 "	Inches and halves.
1" = 1'	576	48	30° 00'	1 "	"
1" = 1'	384	32	48° 35'	1 "	"
1" = 1'	576	48	30° 00'	1 "	Inches, $\frac{1}{2}$ s. and $\frac{1}{4}$ s.
1" = 1'	384	32	48° 35'	1 "	"
1" = 1'	576	48	30° 00'	1 "	Inches, $\frac{1}{2}$ s. and $\frac{1}{4}$ s.
1" = 1'	384	32	48° 35'	1 "	"
1" = 1'	576	48	30° 00'	1 "	Inches, $\frac{1}{2}$ s. and $\frac{1}{4}$ s.
1" = 1'	384	32	48° 35'	1 "	"

SURVEYORS' SCALES: SCALES OF DECIMAL PARTS OF AN INCH.

Scale.	Lines per Foot.	Lines per Inch.	Angle.	Setting of Pawl.
1" = 100'	1200	100	13° 53'	1 Tooth
1" = 90'	1080	90	15° 28'	1 "
1" = 80'	960	80	17° 23'	1 "
1" = 70'	840	70	20° 05'	1 "
1" = 60'	720	60	23° 31'	1 "
1" = 50'	600	50	28° 42'	1 "
1" = 40'	480	40	36° 52'	1 "
1" = 30'	360	30	53° 08'	1 "
1" = 20'	240	20	36° 52'	2 Teeth.
1" = 10'	120	10	53° 08'	3 "

METRIC SCALES.

Scale.	Lines per Metre.	Lines per Foot.	Angle.	Setting of Pawl.	Graduates to
1 Met. = 100 cm.	1000	304.79	70° 54'	1 Tooth.	Millimetres.
1" = 1 m. 25	1600	487.67	36° 12'	1 "	mm. and halves.
1" = 1.33 $\frac{1}{3}$	1500	457.19	39° 03'	1 "	"
1" = 1.66 $\frac{2}{3}$	1200	365.75	51° 53'	1 "	"
1" = 2.00	2500	761.98	28° 12'	1 "	mm. and fifths.
1" = 2.50	2000	609.59	28° 12'	1 "	"
1" = 3.00	1666 $\frac{2}{3}$	507.99	34° 32'	1 "	"
1" = 3.33 $\frac{1}{3}$	1500	457.19	30° 03'	1 "	"
1" = 4.00	1250	380.99	49° 06'	1 "	"
1" = 5.00	2000	609.59	28° 12'	1 "	mm. and tenths.

This book should be returned to
the Library on or before the last date
stamped below.

A fine of five cents a day is incurred
by retaining it beyond the specified
time.

Please return promptly.

